2013

# Three essays on green supply chain management

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**Three essays on green supply chain management**

by

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A dissertation submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Major: Business and Technology (Supply Chain Management)

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2013

# DEDICATION

I would like to dedicate the dissertation to my husband, Dr. Yu Jin, for his support and patience. I would also like to thank my parents for their support and encouragement all these years.

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# ACKNOWLEDGEMENTS

I would like to express my gratitude to all those who helped me with various aspects of conducting research and writing papers. First and foremost, I would like to take this opportunity to express my thanks to my Co-chairs: Dr. David Cantor and Dr. Frank Montabon for their guidance, patience and support throughout my research and the writing of this dissertation. Their insights and words of encouragement have often inspired me towards new height of research. The completion of the dissertation would have been impossible without them.

I also wish to express my warm and sincere thanks to my committee members for their efforts and contributions to this work: Dr. Jennifer J. Blackhurst, Dr. Michael R. Crum, and Dr. Frederick O. Lorenz.

# ABSTRACT

The dissertation includes three essays. These three empirical studies apply structural equation modeling (SEM) to examine key issues in green supply chain management. The hypothesized model is tested using a sample of supply chain managers derived from a Dun and Bradstreet database. The data collection is through a large web-based survey. The first essay examines how a firm's proactive environmental management strategy influences operational performance. The second essay examines the effect of how top management responds to pressure from a firm's rivals and stakeholders to implement green supply management practices. The last essay examines how environmental management competitive pressure from main competitors influences a firm to pursue and produce new environmental innovations into the marketplace (e.g., focal firm's green success) through its green supply chain integration activities.

# CHAPTER 1

# GENERAL INTRODUCTION

Green supply chain management is an important strategy management and operations management topic. In recent years, environmental management has evolved to include boundary-spanning activities, which requires various degrees of interaction with suppliers and customers in the supply chain. That is, in addition to the greening of internal processes, an organization needs to integrate green strategies into its entire span of supply chain activities, which is called green supply chain management (GSCM). Many large companies that focus on sustainable strategies, like Baxter and Wal-mart, have launched green supply chain programs designed to promote environmental management practices throughout their supply chain network. Research has shown that firms with wider arcs (i.e., those that have stronger ties to trading partners in both upstream and downstream directions) achieve superior performance (Frohlich and Westbrook 2001; Schoenherr and Swink, 2012). It stands to reason that this would be the same for environmental initiatives. This concept was supported in past studies (Bowen et al. 2001; Handfield et al. 1997; Zhu and Sarkis, 2004) where it was found that successful firms are ones that integrate environmental strategies across the supply chain activities. Yet, the adoption of green supply chain management (GSCM) has significant barriers to overcome. For example, multiple complexities and uncertainties are important hurdles when companies seek to undertake GSCM practices in their operations. Inter-organizational and cross-functional integration of environmental, production, engineering, marketing, and logistics personnel and their concerns exemplify the characteristics of effective GSCM that contribute to these complexity and uncertainty considerations (Sarkis, 2006). For a manufacturing company to reap effective performance gains from GSCM practice adoption, coordination, and integration of both internal, e.g. management support, and external GSCM practices such as cooperation with suppliers and customers is required (Lee and Klassen 2008). Thus, although there are growing studies on the GSCM, issues of the GSCM remain challenging, requiring more investigations (Sheu and Talley, 2011). More empirical studies needed to examine the outcomes of GSCM as this will affect firms' willingness to implement. To fully reap the benefits from implementing GSCM, academics and practitioners also need to understand which factors lead to the adoption of GSCM and what processes enable GSCM to influence firm performance and supply chain performance. Therefore, this dissertation study aims to further the understanding about the determinants and effects of green supply chain management.

The dissertation includes three essays. These three empirical studies apply structural equation modeling (SEM) to examine key issues in GSCM. The hypothesized model is tested using a sample of supply chain managers derived from a Dun and Bradstreet database. The data collection is through a large web-based survey. The first essay examines how a firm's proactive environmental management strategy influences operational performance. Based on the strategy-structure-capabilities-performance framework (SSCP), a model is developed that describes how effective environmental collaboration with suppliers and environmental innovation serve as important mechanisms that enable firms to act more competitively. Study findings demonstrate that corporate environmental proactivity is an important factor that contributes to a firm's operational performance improvement.

The second essay examines the effect of how top management responds to pressure from a firm's rivals and stakeholders to implement green supply management practices. The Schumpeterian economics view of competition and stakeholder theory are combined to explain the role that the external environment has on how a firm responds to sustainability pressures to implement green supply practices. The study also integrates previous top management literature to examine the nomological model. Study findings offer empirical support of the role of top management support in linking competitive pressure from rivals, stakeholder pressure and three dimensions of green supply management practices implementation. The results of this study indicate that rival pressure and stakeholder pressure influence green supply management implementation through the important role of top management support of environmental management practices.

The last essay examines how a main competitors' green success influences a firm to pursue and produce new environmental innovations into the marketplace (e.g., focal firm's green success) through its green supply chain integration activities. Supply chain integration (SCI) consists of a focal firm's collaboration with internal cross-functional teams, external customers, and suppliers. In this study, the term green supply chain integration (GSCI) is used to describe three forms of collaboration -- internal integration of green product development, customer integration of green product development, and supplier integration of green product development. The Schumpeterian perspective of competition is based to build the research model. The empirical results provide the evidence that main competitors' green success is an important determinant for a firm to adopt green supply chain integration activities and then introduce environmental innovations to the marketplace. By differentiating incremental environmental innovation and radical environmental innovation, this study also reveals the role of three dimension of green supply chain integration on incremental and radical environmental innovation separately. Empirical evidence demonstrates the relative importance of internal integration and external supplier and customer integrations in developing incremental and radical environmental innovation. This study is among the first studies to examine supply chain integration in the domain of green product development and environmental innovation.

The rest of the dissertation is organized as follows. Chapter 2 presents the first essay with a title of Examining corporate environmental proactivity strategy and operational performance: A supplier collaboration and environmental innovation perspective. Chapter 3 presents the second essay with a title of An examination of how a firm's rivals and stakeholders influence green supply management practices. Chapter 4 presents the third essay with a title of Exploring how environmental management competitive pressure affects a focal firm's environmental innovation activities: A green supply chain perspective. Chapter 5 concludes the dissertation by introducing general contributions of this dissertation and suggesting some directions for future research.

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# CHAPTER 2

# EXAMING CORPORATE ENVIRONMENTAL PROACTIVITY AND OPERATIONAL PERFORMANCE: A SUPPLIER COLLABORATION AND ENVIRONMENTAL INNOVATION PERSPECTIVE

## 2.1 Introduction

Environmental management is a topic of increasing interest in supply chain management (SCM) (Kleindorfer, Singhal, and Van Wassenhove, 2005; Linton, Klassen, and Jayaraman, 2007; Montabon, Sroufe, and Narasimhan, 2007; Hofer, Cantor, and Dai, 2012). A steady stream of SCM research provides empirical evidence that implementing environmental management activities may result in improved firm performance. For example, Klassen and McLaughlin (1996) find that announcements of environmental management practices improve a firm's market valuation. Similarly, Montabon, Sroufe, and Narasimhan (2007) present findings that environmental management activities are associated with product innovation, process innovation, and sales growth. Jacobs, Singhal, and Subramanian (2010) find that the market reacts to certain types of announcements (e.g., philanthropic gifts for environmental causes, voluntary emission reductions, and announcements of ISO 14001 certification). Hence, there is mounting evidence that environmental management activities afford the firm the opportunity to reduce the negative impact on the environment (e.g., reduce the amount of emissions and waste generated) while at the same time improving operational performance (Hofer et al., 2012).

While the above mentioned research, among many others has made an important contribution to the literature, scant research has explored the strategic and supply chain collaborative mechanisms through which environmental management impacts environmental innovation and operational performance. For instance, environmental activities require the firm to proactively engage suppliers in the procurement of sustainable materials (Corbett and Klassen, 2006; Jacob et al., 2010). Similarly, Cantor, Morrow, and Montabon (2012) describe how firms institute certain management practices and reward structures which can foster increased levels of employee commitment to environmental behaviors (e.g., the providing of innovative environmental ideas and suggestions on environmental initiatives). Thus, these and many other examples demonstrate that for environmental management practices to affect firm performance, a firm needs to mobilize its supply chain collaborative resources proactively (Walley and Whitehead, 1994; Cantor et al., 2012).

The purpose of this study is to develop a model how a firm's proactive corporate environmental management strategy influences firm environmental innovation and operational performance from a strategy-structure-capabilities-performance (SSCP) perspective (Chen, Daugherty, and Landry, 2009).In so doing, this research seeks to fill several gaps in the literature and thus makes important contributions to the field of supply chain management. First, our study represents the first empirical testing of the strategy-structure-capabilities-performance framework (SSCP) (Chen, Daugherty, and Landry, 2009) in an environmental management innovation and operational performance context. Specifically, we propose that the effect of corporate environmental proactivity on a firm's operational and innovative performance occurs through a firm's engagement in environmental collaboration activities with its suppliers. Second, Ferguson, Schmidt, and Souza (2010, p. 248) point out that "there is little academic literature on the interface between innovation and sustainability, from an operations management perspective." We respond to this call for research by theorizing from a SSCP perspective and empirically testing the notion that environmental collaboration with suppliers and environmental innovation are distinctive resources which enable the firm to improve operational performance. Fourth, this study sheds light on the effective role of a firm's environmental collaboration with its suppliers on developing environmental innovations and overall operational performance and thus contributes to and extends the growing literature on green supply chain management such as Zhu and Sarkis (2004), Linton et al. (2007), and Vachon and Klassen (2008).

The remainder of this paper is organized as follows. The following section is the literature review. The third section develops the conceptual framework and hypotheses. In the fourth section, we present the methodology and in the fifth section discuss the results. In the last two sections, we discuss both the theoretical and managerial contributions of the research and provide a summary and conclusion to the paper.

### 2.2 Literature Review

A steady stream of prior research has examined the antecedents of environmental management practices in the field of supply chain management. External factors include legislation and regulation, stakeholder pressures (Delmas and Toffel, 2004; Sarkis, Gonzalez-Torre, and Adenso-Diaz, 2010) and competition pressure from rivals (Hofer et al., 2012). Top management commitment (Gattiker and Carter, 2010), resource and management system availability (Aragón-Correa and Sharma, 2003), and communication and training (Sarkis et al., 2010) are also highlighted as important operational level antecedents. Individual level attitudes, experiences and preferences have also been identified as important predictors of environmental commitment (Pagell and Gobeli, 2009; Cantor et al., 2012).

A burgeoning amount of research has examined the effect of environmental management practices on firm performance. Some studies have identified environmental management practices as a source of competitive advantage that can improve a firm's environmental performance, market performance, operational performance, and financial performance. For example, based on survey data, Melnyk, Sroufe, and Calantone (2003) demonstrate that firms which adopt environmental management practices will improve environmental and operational performance. Zhu and Sarkis (2004) find that green supply chain management practices can improve a firm's operational and economic performance. Montabon, Sroufe, and Narasimhan (2007) use secondary data from corporate sustainability reports to explore the relationship between environmental management practices and firm performance and find that environmental management practices are positively correlated to financial performance.

While the above mentioned studies, among many others, represent an important contribution to the literature, we believe that limited research has drawn from the strategy-structure-capabilities-performance framework (SSCP) and examined the process through which environmental management practices impact firm environmental innovation and operational performance. Our research seeks to fill this void in the literature by examining the effect of supplier-related environmental management activities, in particular how a firm's collaboration with suppliers affects firm performance. Indeed, many companies are now focusing on sustainable strategies, including Baxter and Wal-mart, by launching green supply chain programs designed to promote environmental management practices throughout their supplier network (Baxter, 2010; Walmart, 2011). These phenomena highlight the need to examine the effect of supplier collaboration on environmental management. Therefore, based on the SSCP framework, we propose that a firm's environmental collaboration with its suppliers affects a firm's environmental innovation and thus acts as an important mechanism to improve firm operational performance.

## 2.3 Theoretical Framework

### 2.3.1 Strategy-structure-capabilities-performance (SSCP) framework

The theoretical perspective of this study is the strategy-structure-capabilities-performance framework (SSCP) (Chen, Daugherty, and Landry, 2009). The SSCP framework is derived from the strategy-structure-performance framework that is used in the strategic management discipline (Waldman and Jensen, 2001). The SSCP framework also contains elements from the resource-based view (RBV) theoretical concept as well (Barney, 1991). This SSCP theoretical framework purports that a firm can secure competitive advantage in the marketplace because the firm aligns its strategic priorities (e.g., cost orientation and/or customer orientation) with their supply chain processes and capabilities to enhance firm performance (Chen et al., 2009). In so doing, the firm can leverage its valuable, rare, and difficult to imitate supply chain processes and resources. In the context of this study, we propose that a firm's proactive environmental management strategy is an important strategic priority and resource. Companies make its environmental management activities a strategic priority to reduce the firm's impact on the natural environment and recognize the possible competitive advantage associated with investing in environmental management practices.

A company with a proactive environmental management strategy has some distinctive resources. These distinctive resources include physical assets and technology, human resources, organizational capabilities, and intangible resources such as reputation that can create a sustained competitive advantage (Russo and Fouts, 1997). In this line, Porter and van der Linde (1995a) propose that environmental management enables firms to develop and introduce innovations to the market and that the benefits, such as resource productivity, derived from these innovations may offset the cost of implementing environmental management and enable the firm to act more competitively. Moreover, Sharma and Vredenburg (1998) identify three key capabilities derived from a proactive environmental management strategy including: capability for stakeholder integration, capability for higher-order learning, and capability for continuous innovation. Thus, collaborating with suppliers on the exploration of new environmental management practices can increase a firm's capability to engage in higher-order learning on the generation of new technological, organizational and operational environmental innovations on a continuous basis (González-Benito and González-Benito, 2005).

Following the SSCP and RBV perspectives, we provide the following overview of our model. The more proactive a firm's corporate environmental management strategy, the higher a firm's operational performance. Additionally, a higher level of proactive corporate environmental management strategy is positively associated with a higher level of environmental collaboration with suppliers. The higher level of environmental collaboration with suppliers will result in a stronger association with both incremental and radical environmental innovation. Lastly, both incremental and radical environmental innovation is positively related to operational performance improvement. Figure 2.1 illustrates our proposed research model.

**2.3.2 The effect of corporate environmental proactivity on operational performance**

The first element of our SSCP framework is a firm's strategic priority to pursue corporate environmental management activities proactively. The natural resource-based view of the firm perspective (e.g., Hart, 1995; Sharma and Vredenburg, 1998; Klassen and Whybark, 1999; Christmann, 2000), indicates that firms with a proactive environmental management strategy can improve firm performance including resource efficiency, reduction in energy usage, raw material and abatement cost, and the production of high quality products that can reduce environmental burden. Firms with a proactive environmental management strategy can also leverage their intangible resources such as a good organizational reputation thus making it easier to attract top candidates to work in the company. Strong human resource practices enable the firm to create production systems that maximize resource efficiency and minimize harmful ecological impacts (Pagell and Gobeli, 2009). Moreover, several empirical studies have provided evidence that a positive direct relationship exists between proactive environmental management and operational performance (e.g., Melnyk et al., 2003; González-Benito and González-Benito, 2005; Pagell and Gobeli, 2009). Therefore, we propose:

*H1:* Corporate environmental proactivity has a positive influence on a firm's operational performance.

**2.3.3 The effect of corporate environmental proactivity on environmental collaboration with suppliers**

The next linkage in our SSCP model is the relationship between a firm's corporate environmental proactive strategy and the environmental collaboration supply chain processes that exist with the firm's suppliers. Collaboration across the supply chain is key to the successful pursuit of environmental management activities in today's sustainable supply chains (Rao, 2002; Vachon and Klassen, 2006). In this study, our focus is on environmental collaboration with suppliers which is defined as those "activities comprising a direct involvement of the buying organization with its suppliers to jointly develop environmental solutions" (Vachon and Klassen, 2006, p. 798) and includes early supplier involvement, joint efforts, assistance, training, and communication. Environmental collaboration with suppliers requires the buying firm to devote specific resources and considerable investment to the development of cooperative activities to address environmental issues. Collaborating with suppliers on environmental management shows a proactive posture of a company toward environmental management initiatives.

Many studies provide evidence that a firm with a proactive environmental management strategy is more likely to implement environmental collaboration activities (e.g., Walton, Handifield, and Melnyk, 1998; Bowen, Cousins, Lamming and Faruk, 2001). An environmentally proactive firm thrives not only when it engages executives and workers within the firm, but also when the firm involves customers and suppliers into its environmental planning and operations processes (Makower, 1994). This implies that an environmentally proactive firm will gain greater benefits from its environmental management practices when it closely integrates suppliers in the supply chain into its environmental management supply chain process. Therefore, we propose:

*H2:* Corporate environmental proactivity has a positive influence on a firm's environmental collaboration with suppliers.

**2.3.4 The effect of environmental collaboration with suppliers on environmental innovation**

The SSCP framework also provides insights into how and why environmental collaboration affects environmental innovation. Firms increasingly rely on external knowledge to engage in innovation activities. An important source of external knowledge is the close interactions and relationships that a firm develops with it supply base (Chen et al., 2000). A firm's suppliers have a wealth of information and experience with different technologies and supply chain processes (Teece, 2009; Swink, 2006). Ahuja (2000) notes that collaboration with suppliers would not only provide the benefit of resource sharing (i.e., allowing firms to combine knowledge, skills and physical assets), but also provide access to knowledge spillovers. Although these arguments about the effect of supplier collaboration on innovation refer to innovation generally, growing research has begun to examine the effect of supplier collaboration on environmental innovation specifically and provide similar arguments that knowledge from suppliers is essential and an important component to the development of successful environmental innovation efforts (e.g., Geffen and Rothenberg, 2000; Rao, 2002).

Environmental innovation is defined as a specific kind of technical innovation that consists of new products and processes to avoid or reduce environmental burden (Ziegler and Nogareda, 2009). Environmental innovation has been examined from both an incremental and radical innovation perspective. In our study, incremental environmental innovation refers to minor improvements or simple adjustments in existing environmental technologies including green products and environmental management processes (Arundel et al., 2007; Li, Liu, Li and Wu, 2008). Radical environmental innovation refers to fundamental changes that represent revolution in environmental technology including green products and environmental management processes (Arundel et al., 2007; Li et al., 2008; Slocum and Rubin, 2008). Arundel, Kemp, and Parto (2007) note that a better understanding of the factors that encourage the development of radical and/or incremental environmental innovation would be of value to environmental policy makers and company environmental strategists. In order to further our understanding of the role of suppliers in the development of environmental innovation, we examine environmental innovation from both an incremental and radical environmental innovation perspective.

Firms that collaborate with their suppliers are able to engage in both incremental and radical environmental innovation. Collaboration practices include early supplier involvement, buying firms' assistance (such as technical assistance, training, education and site visits), joint efforts, and communication. Integrating suppliers into environmental activities helps a firm to identify potential technical problems, such as contradictory specifications or unrealistic designs, early in the design-for-environment (DOE) process and thus speeds up both incremental and radical environmental innovation development and responses to market demands (Kessler and Chakrabarti, 1996). Integrating suppliers into the environmental innovation development process also facilitates outsourcing and external acquisition possibilities thereby reducing the internal complexity of environmental innovation projects and shortening the critical path for environmental innovation development.

Previous literature has proposed that the capability of suppliers plays an important role in a firm's ability to engage in innovation and new product development (Song and Benedetto, 2008). Unfortunately suppliers do not always have the capability to comply with the buying firm's innovation needs. Through technical assistance, training, education and site visits, buying firms could help suppliers develop appropriate capacity for environmental innovation in return for the benefits of more useful knowledge, improved performance and joint value creation (Krause, Handfield, and Tyler, 2007). The buying firm's assistance also signals to the supplier that the buying firm has confidence in the supplier's long-term capabilities to meet its environmental management needs and thus build the supplier's confidence in the relationship's continuity. Accordingly, the supplier is motivated to engage in reciprocal behavior (Henke and Zhang, 2010), such as customer-specific environmental innovation investment to help develop the buying firm's incremental or radical environmental innovation requirements.

Joint efforts and communication within the buyer-supplier collaboration effort helps the supplier to better understand the buying firm's plans and expectations in environmental management and decrease inter-firm conflict. Moreover, through open and honest communication and joint efforts, firms could create a supportive and trusting environment to facilitate and increase the supplier's commitment to their relationship thus facilitating acts of both incremental and radical innovation (Henke and Zhang, 2010). The supplier's commitment, demonstrated by a supplier's willingness to invest in environmental technology and to share environmental technology with a buying firm, is an important component of both incremental and radical environmental innovation in the networked environment (Gundlach, Achrol, and Mentzer, 1995). As an example of radical environmental innovation, Microsoft has formed strategic partnerships to promote green technology, such as a project known as the Green Grid, which is designed to use IT to promote sustainability (DuBois, 2011). Amazon has worked with suppliers such as Philips to cut out the clamshells and stick with boxes that are made from recyclable materials, which is an example of incremental environmental innovation (DuBois, 2011). In sum, we propose:

*H3a:* Environmental collaboration with suppliers has a positive influence on a firm's incremental environmental innovation.

*H3b:* Environmental collaboration with suppliers has a positive influence on a firm's radical environmental innovation.

**2.3.5 The effect of environmental innovation on operational performance**

The SSCP framework points out that a firm's supply chain capability (e.g., environmental innovation) affects operational performance. Briefly, operational performance includes improvements in cost reduction, quality, delivery and flexibility (Ferdows and De Meyer, 1990). Chen et al. (2009) point out that a supply chain's innovative capability can contribute to a firm's performance improvements. In fact, Das and Joshi (2007) shows that innovativeness affects financial performance. We build-upon these previous studies by describing that there are numerous benefits when a firm engages in environmental innovation. For example, through the pursuit of acts of incremental environmental innovation a firm can reduce its operating costs and improve the quality of its products. Radical environmental innovation may provide greater environmental benefits as well (Arundel et al., 2006) and improved operational performance, including cost reduction (Hall and Kerr, 2002; Slocum and Rubin, 2008). Generally, environmental innovation contributes to a firm's operational performance in several ways. First, incremental and radical environmental innovation involves redesigning production processes to be less polluting. The companies can substitute less polluting inputs into the production process and implement recycling by-products of processes. These innovative actions could improve product quality and reduce the cost of production not only by increasing the efficiency of production processes but also by reducing input and waste disposal costs (Hart, 1995; Shrivastava, 1995a, b; Hart and Ahuja, 1996; Christmann, 2000). For example, by cutting wasteful packaging, Amazon reduced its carbon footprint and improved delivery performance. Southwest Airlines is making incremental innovation changes such as adding lighter-weight carpeting, seat covers, and life vests to become even more fuel-efficient, which translates to lower operational cost (DuBois, 2011). Second, in the process of developing incremental and radical environmental innovation, inefficiencies in existing production processes or products that were not previously recognized might be realized by managers thereby increasing the potential for cost-saving efficiency and delivery speed, quality, and flexibility improvements (Porter and van der Linde, 1995a, b; Christmann, 2000). Third, environmental innovation could impact a firm's operations throughout its entire product life cycle – from purchasing, through manufacture, distribution, use to disposal, and thus contribute to cost reduction (Christmann, 2000). Lastly, companies that seek improvements in their operational capabilities may rely on their innovation capabilities. In the absence of innovation, improvements in operational capabilities may be inconsequential (Koufteros, Cheng and Lai, 2007). But with environmental innovation, products closely match current customer demands and expectations for environmental sustainability. For example, because customers want their laundry to be both clean and green, Procter and Gamble made investments into research and development activities that lead to a radically eco-friendly cold water detergent. Thus, this act of environmental innovation helps customers reduce the amount of energy used to heat water for their laundry (DuBois, 2011). Therefore, we propose:

*H4a:* Incremental environmental innovation has a positive influence on a firm's operational performance.

*H4b:* Radical environmental innovation has a positive influence on a firm's operational performance.

## 2.4 Methodology

### 2.4.1 Survey development

To study our hypothesized relationships, a web-based survey instrument was developed. We developed our survey instrument by following procedures and guidelines recommended by Churchill (1979), Gerbing and Anderson (1988), and Dillman (2000). The design process for the questionnaire consisted of two stages. The first stage involved an extensive review of the literature to help identify the constructs in the model. Established measures were adopted directly or modified slightly to measure each of the constructs. This process involved making word and sentence changes so that all items fit the environmental management context. In the second stage, the preliminary draft questionnaire was reviewed by 17 industry practitioners (mid- or senior-level supply chain managers) and MBA students for ambiguity, readability, and clarity purposes. Two SCM professors and four PhD students reviewed the survey for item specificity, face validity and content validity. The questionnaire was revised based on feedback from both practitioners and academics.

### 2.4.2 Administration of survey

To ensure data confidentiality, the web-based survey was administered by a large public Midwestern university. Following the recommendations of Dillman (2000) and to increase survey response rate, we notified in advance 3,490 potential supply chain professional respondents by phone about our survey. In so doing, we hired and trained undergraduate and graduate student research assistants to telephone and email potential survey respondents based on a database that was acquired from the Dun and Bradstreet (D&B) Company. As described by Dillman (2000), pre-notifying potential survey respondents helps to improve survey response rates. Moreover, survey respondents were motivated to participate in this study because the subject matter of our questionnaire is viewed as a current topic that could impact the key informant's profession. After calling potential survey respondents, our student research assistants emailed the D&B contacts with a link of the online questionnaire along with a brief explanation which described the study's objectives. Our student research assistants also made follow-up telephone calls and sent reminder emails about our study as suggested by Dillman (2000). Additionally, to encourage participation in the research project, we offered a summary of the results to the survey respondents (Dillman, 2000).

### 2.4.3 Sample

The population for the survey was drawn from supply chain management professionals who are employed by publicly traded firms in the United States as reflected in D&B database. Of those respondents that we were able to contact by telephone, 197 respondents formally declined to participate in the survey because of company policy or other time commitments. Based on the student research assistant telephone and email follow-up information, we identified that 1,425 respondents are no longer employed by their organization and 419 potential professional contacts were not reachable by telephone or email because of either invalid email addresses or the phone numbers derived from the D&B database are no longer in service. A total of 1,449 potential respondents received an emailed link to the survey. We received 264 responses. After excluding 34 incomplete survey responses, 230 useable observations were retained out of 1,449 contacts, resulting in a response rate of approximately 16% (230/1,449).

We checked for potential non-response bias by comparing early and late responses for all of the constructs in our model using one-way analysis of variance (ANOVA) (Armstrong and Overton, 1977). There are no statistically significant differences between the early and late respondent groups. We also evaluated non-response bias by comparing the survey respondents with non-respondents against firm and industry characteristics including firm size, the Herfindahl–Hirschman Index (HHI), and return on assets (ROA). No significant differences were found between the respondents and non-respondents. Therefore, we believe survey non-responses bias is not a serious concern.

Over eighty percent (81.7%) of the respondents are from manufacturing industries. Seventy-six percent of the survey respondents hold the position of a manager or higher. About ninety-six percent of the survey respondents have more than ten years of work experience. On average, the key informant worked for a company where total sales are approximately $5.9 billion.

**2.4.4 Independent and dependent variables**

The variables used in this study are based on well-established items in the supply chain management literature. A complete list of the items used is provided in Appendix 2.A.

Corporate environmental proactivity

Our key independent variable, corporate environmental proactivity, is derived from Bowen, Cousins, Lamming and Faruk (2001). The construct corporate environmental proactivity describes a firm's proactive environmental management strategy. Respondents were asked to rate each item on this construct using a seven-point response format that is anchored from 1 (strongly disagree) to 7 (strongly agree). The Cronbach alpha is 0.919.

Environmental collaboration with suppliers

We measured environmental collaboration with suppliers based on items developed by Vachon and Klassen (2006). Respondents were asked to rate each item on a seven-point response format that is anchored from 1 (very low) to 7 (very extensive). The Cronbach alpha is 0.970.

Incremental and radical environmental innovation

Next, we examined the extent to which the firm engages in incremental and radical environmental innovation. Our measures of incremental and radical environmental innovation measures are derived from Li, Liu, Li and Wu (2008). As discussed earlier, we define incremental environmental innovation as minor improvements or simple adjustments in existing environmental technologies, including green products and environmental management process. Radical environmental innovation is defined as fundamental changes that represent revolution in environmental technology including green products and environmental management process. Respondents were asked to respond to the incremental and radical environmental innovation items using a seven-point response format from 1 (strongly disagree) to 7 (strongly agree). The Cronbach alpha is 0.951 for incremental environmental innovation and 0.982 for radical environmental innovation.

Operational performance

Research has suggested operational performance includes four important components: cost, quality, delivery and flexibility. Based on previous literature (Devaraj, Krajewski, and Wei, 2007; Azadegan and Dooley, 2010; Inman, Sale, Green Jr., and Whitten, 2011), our dependent variable, operational performance, is designed to be a four-item scale with each item corresponding to cost, quality, delivery and flexibility, respectively. Respondents were asked to rate each item on a seven-point scale anchored at 1(strongly disagree) to 7 (strongly agree). The Cronbach alpha is 0.967.

Control variables

We now turn to describing the control variables specified in our model. First, we controlled for the size of the firm as large firms tend to have access to more resources than smaller firms. Firm size is defined as total sales. Because this variable may be skewed, we transformed this variable using the natural log. Second, we controlled for the firm's research and development (R&D) expenditures. Firms engaged in innovative activities dedicate more resources to R&D. Because firms make R&D investments across multiple time periods, we created a five year time-weighted R&D stock variable (2006-2010) where the most recent year is weighted the most. Thirdly, we controlled for industry competitiveness as measured by the Herfindahl–Hirschman Index (HHI) at the 3-digit NAICS level. Finally, we controlled for the financial performance of the firm as measured by return on assets (ROA). All of our control variables were derived from the Compustat database in the year 2010 unless otherwise noted above.

## 2.5 Analysis and Results

We examined the reliability and validity of our constructs using Mplus 6.0 and SPSS 19.0. In particular, we adopted Gerbing and Anderson's (1988) two-step approach, which consists of first examining the measurement model and then the structural model to analyze the data. We assessed the measurement model, including convergent validity and discriminant validity in order to assure that the measures used in the analysis are reliable and valid. Table 2.1 presents descriptive information on each variable and the correlations across constructs.

**2.5.1 Measurement instrument validation**

Construct validity is the extent to which the items on a scale measure the abstract or theoretical construct of interest (Churchill, 1979). Convergent validity exists if a group of indicators are measuring one common factor. A loading of 0.70 indicates that about one-half of the item's variance (the squared loading) can be attributed to the construct, thus, 0.70 is the suggested minimum level for item loadings on established scales (Fornell and Larcker, 1981). While a majority of our items have high loadings, one of the corporate environmental proactivity items was dropped due to low factor loading. Composite reliability and average variance extracted were calculated using the procedures suggested by Fornell and Larcker (1981). Composite reliability (CR) for each construct is 0.923 or greater, and average variance extracted is 0.665 or greater. Cronbach's alpha values of all factors are well above 0.70. Table 2.2 provides all of these values and suggests sufficient convergent validity.

Discriminant validity among the constructs was assessed by first evaluating whether the intercorrelation among the constructs is less than 0.70, which suggests the constructs have less than half their variance in common. All pairs of constructs meet this threshold. Discriminant validity was also assessed by comparing the average variance extracted (AVE) for each construct with the square of the correlation between all possible pairs of constructs (Hair, Black, Babin, and Anderson, 2010). In all cases, the AVE is greater than the square of the correlation between all possible pairs of constructs (See Table 2.3). Additionally, the overall measurement model provides a good fit to the data ($\chi 2$=670.814, Dof=296, p=0.00, CFI=0.962, TLI=0.954, and

RMSEA=0.074). Overall, the results offer support for discriminant validity among the constructs.

**2.5.3 Common method bias**

Our study employed multiple methods to mitigate any potential effects of common method bias. First, we surveyed supply chain managers of each firm who are knowledgeable about their operations and hence minimizes the potential of common method bias (Miller and Roth, 1994). Second, we combined secondary data with survey data in our model in order to reduce common method bias (Boyer and Swink, 2008). Third, we performed Harman's single factor test for survey data using a confirmatory approach in order to assess the degree of common method bias in the data ($\chi 2$=670.814, Dof=230, p=0.00, CFI=0.544, TLI=0.499, and RMSEA=0.289). Our Harmon's single factor test results are considerably worse than those of the measurement model. This suggests that a single factor is not acceptable, thus further suggesting that common method bias is not a concern. Fourth, to further assess common method bias, we tested a measurement model having only the traits (trait-only model) first and then added a single method factor to the trait-only model (Widaman, 1985; Podsakoff, MacKenzie, Lee, and Podsakoff, 2003). The results of this test indicate that the added method factor only accounts for 6.4% of the total variance, which is significantly less than the amount of method variance (25%) observed by Williams, Cote and Buckley (1989) in their analysis of common method variance in self-reported data. Also, the item loadings for their factors are still significant even when the method factor is included in the model. Finally, following the approach recommended by Lindell and Whitney (2001), we checked for the impact of method variance by using the lowest bi-variate correlation among the manifest variables as the marker variable. We computed the adjusted correlation matrix and tested the significance of the adjusted correlations.

All correlations remain significant after the adjustment. Lindell and Whitney (2001, p. 118) state that "if any zero-order correlations that were statistically significant remain significant, this suggests that the results cannot be accounted for by CMV." Based on the above findings, it is reasonable to conclude that common method bias is not a serious concern in this study.

**2.5.4 Hypotheses testing**

We tested our hypotheses using Mplus 6.0. The fit indices of our measurement model meet the cut-off values suggested by Hu and Bentler (1999) ($\chi2$=692.718, Dof=312, p=0.00, $\chi2$/Dof=2.22, CFI=0.961, TLI=0.956, and RMSEA=0.073).

All hypotheses are supported. As expected, corporate environmental proactivity (a firm's proactive environmental management strategy) is positively related ($\beta$=0.142, $p<.01$) to a firm's operational performance (H1). Corporate environmental proactivity is also positively related ($\beta$=0.382, $p<0.001$) to environmental collaboration with suppliers (H2). Environmental collaboration with suppliers has a positive relationship ($\beta$=0.649, $p<0.001$) with the development of incremental environmental innovation (H3a) and has a positive relationship ($\beta$=0.635, $p<0.001$) with the development of radical environmental innovation (H3b). Incremental environmental innovation is positively related ($\beta$=0.434, $p<0.001$) to operational performance (H4a). Radical environmental innovation has the expected positive effect ($\beta$=0.403, $p<0.001$) on operational performance (H4b). None of the control variables have a significant effect on operational performance. We will discuss the implications of our findings in the discussion section.

**2.5.5 Competing models**

When using structural equation methodology, it is common to present alternative models to demonstrate which model fits the data best (Cudeck and Browne, 1983; Bollen and Long, 1992). We thus compared our hypothesized model (Model 1) to three rival models to further validate that our hypothesized model is a strong model. Model 2 (a fully mediated model) consists of testing all indirect effects, i.e., dropping the direct path from corporate environmental proactivity (CEP) to operational performance (OP) in Model 1. Model 3 is created by starting with Model 1 and then adding a direct path from environmental collaboration with suppliers (EC) to operational performance (OP). Model 4 (direct effects model) only tests all direct effects of corporate environmental proactivity (CEP), environmental collaboration with suppliers (EC), incremental environmental innovation (IEI), and radical environmental innovation (REI) on operational performance (OP), which means dropping the direct paths from corporate environmental proactivity (CEP) to environmental collaboration with suppliers (EC), from environmental collaboration with suppliers (EC) to incremental environmental innovation (IEI) and from environmental collaboration with suppliers (EC) to radical environmental innovation (REI) in Model 1.

Model 1, Model 2 and Model 3 are nested, therefore we employ a $\chi 2$ difference test (Rust, Lee, and Valente Jr., 1995) to determine which model is better (Shah and Goldstein, 2006). The $\chi 2$ difference when comparing the Model 1 and Model 2 was statistically significant ($\Delta\chi 2=8.35$, Dof=1, $p<0.01$), and thus Model 2 is rejected, suggesting the proposed model (Model 1) fits better than the fully mediating model (Model 2). The $\chi 2$ difference when comparing Model 1 and Model 3 was not statistically significant ($\Delta\chi 2=1.528$, Dof=1, $p=0.216$), and thus we can conclude that the two models are not statistically significant different from each other, suggesting the proposed model (Model 1) fits as well as the less restrictive model (Model 3).

Next, we used multiple fit indices to compare model parsimony. These are Akaike's information criterion (AIC), consistent Akaike's information criterion (CAIC), parsimony goodness of fit index (PGFI), and parsimony goodness of fit index (PGFI). A chi-square test is applicable to the nested models; the AIC, CAIC, PNFI and PGFI are applicable to both nested and non-nested models (Schumacker and Lomax, 2004; Shah and Goldstein, 2006). A lower value of AIC and CAIC indicates a more parsimonious model (Schumacker and Lomax, 2004) and thus the smaller AIC and CAIC, the better the model. The cut-off value of PNFI and PGFI are 0.5 and the bigger PNFI and PGFI, the better the model. Table 2.4 shows a comparison of the parsimony fit measures for Model 1 and Model 3. The comparison suggests Model 1 is superior to Model 3.

Model 4 is not nested in Model 1, so we can compare them using PNFI, PGFI, AIC and CAIC (Shah and Goldstein, 2006; Hair et al., 2010). The comparison suggests that our hypothesized model (Model 1) was more parsimonious and superior to the alternative direct model (Model 4) (i.e., AIC and CAIC is lower for Model 1 than Model 4; PNFI and PGFI are higher for Model 1 than Model 4. See Table 2.4). Finally, the additional path from environmental collaboration with suppliers (EC) to operational performance (OP) is not significant in Model 3 and Model 4. Overall, the results provide support that our hypothesized model is a strong model compared to the alternative models.

### 2.5.6 Mediation analysis

We hypothesized that the relationship between corporate environmental proactivity and operational performance is mediated by environmental collaboration with suppliers, incremental environmental innovation, and radical environmental innovation. We also hypothesized that both incremental environmental innovation and radical environmental innovation fully mediate the relationship between environmental collaboration with suppliers and operational performance. To further assess these mediating relationships we conducted several tests. First, in the above section of competing models, we compared Model 1 and Model 3 and demonstrated that our model (Model 1) is strong and thus provides support for full mediation of environmental innovation between environmental collaboration with suppliers and operational performance. The additional direct path from environmental collaboration with suppliers (EC) to operational performance (OP) in Model 3 is not statistically significant. Following the same logic, a competing model analysis between Model 1 and Model 2 provides support that the relationship between corporate environmental proactivity and operational performance is partially mediated by environmental collaboration with suppliers, incremental environmental innovation, and radical environmental innovation since dropping the path from corporate environmental proactivity (CEP) to operational performance (OP) significantly increases the $\chi 2$ value. Thus our hypothesized model has a stronger fit than the fully mediated model (Model 2).

We examined the significance of these indirect effects using the Sobel (1982) test as implemented in Mplus. Assessing the significance of indirect effects is consistent with recent recommendations by several scholars (e.g., MacKinnon, Lockwood, Hoffman, West, and Sheets, 2002; Shrout and Bolger, 2002). All indirect effects are significant at the p=0.001 level (Table 2.5). We further tested the statistical significance of the indirect effects using a bootstrapping approach (n=5000). All indirect effects are significant at p=.001 using a 95% confidence interval (Table 2.5). These results indicate the mediation relationships exist in our model.

## 2.6 Discussion

The purpose of this study is to show the process through which a firm's proactive environmental management strategy influences firm environmental innovation and operational performance. In so doing, we adopt a strategy-structure-capabilities-performance (SSCP) perspective to examine our nomological model (Chen, Daugherty, and Landry, 2009). As mentioned earlier, the SSCP theoretical framework purports that a firm can secure competitive advantage in the marketplace because the firm aligns its strategic priorities with its supply chain processes and capabilities to enhance firm performance (Chen et al., 2009). Our study demonstrates that a firm's proactive environmental management strategy is an important strategic priority. Further, our study provides empirical evidence that a firm's proactive environmental strategy does influence environmental innovation and operational performance through its environmental collaboration efforts. We have theorized and provided empirical evidence of our environmental strategy and firm performance model. It is important to document these relationships because it is highly important for the firm to recognize the possible competitive advantages associated with investing in environmental management practices.

Our study contributes to the literature by increasing our understanding of how relationship between corporate environmental proactivity influences environmental innovation and operational performance. We describe how effective environmental collaboration with suppliers and environmental innovation development are mediating factors of a firm's operational performance. Therefore a first contribution of our investigation is that we examine this process as a way to provide one explanation as to the direct relationship between proactive environmental management and firm performance. Second, this study sheds light on the effective role of environmental collaboration with suppliers on the development of environmental innovation and operational performance and thus we contribute to and extend the growing literature on green supply chain management (Sarkis, Zhu, and Lai, 2010). Lastly, we describe the important role of environmental innovation and sustainability from an operations management perspective. We theorize and empirically test the notion that environmental collaboration with suppliers and environmental innovation are distinctive resources which enable the firm to improve operational performance. These findings provide managerial and theoretical insights to our overall understanding of the nature of the relationship between proactive environmental management and operational performance. We now turn to providing a discussion of how our specific findings contribute to research and the further research ideas they stimulate.

**2.6.1 Theoretical and managerial implications**

Our empirical results indicate that a proactive environmental management strategy has a direct and positive effect on a firm's operational performance (H1). This result is consistent with previous research that is based on the strategy-structure-capabilities-performance (SSCP) perspective and the natural resource-based view of the firm (e.g., Aragón-Correa and Sharma, 2003; Zhu and Sarkis, 2004). 'Win-win' opportunities exist for companies that take a proactive posture to implement environmental management practices. Our results also demonstrate that when companies adopt a proactive environmental management strategy, they are more likely to engage in environmental collaboration with suppliers (H2). Extending environmental management practices across the supply chain, such as collaborating with its suppliers to develop green products and design environmental friendly process, shows a firm's proactive posture toward environmental management and green supply chain management.

We also find that environmental collaboration with suppliers increases both incremental and radical environmental innovation development (H3a, b). Our results complement previous empirical studies which find that greater supplier involvement and collaboration improves new product development (e.g., Petersen, Handfield, and Ragatz, 2005; Koufteros et al., 2007; Song and Benedetto, 2008) and environmental innovation (e.g., Geffen and Rothenberg, 2000). Environmental collaboration with suppliers is noted as an important antecedent for the development of environmental innovation. This can be explained based on the SSCP and resource-based view of the firm (Barney, 1991) which emphasizes the importance of a firm's internal resources. Resources which are valuable, rare, and difficult to substitute or to imitate, are fundamental to the achievement of competitive advantage (Russo and Fouts, 1997) and therefore key for innovative activities (Teece, 2009). Environmental collaboration with suppliers is a firm's knowledge- and relational- based resource (e.g., Geffen and Rothenberg, 2000; Roy, Sivakumar, and Wilkinson, 2004; Vachon and Klassen, 2008), which is more likely to be rare and difficult to copy than some tangible assets (e.g., financial resources).

The results from our model also suggest that supplier environmental collaboration has a great influence on a firm's operational performance through the development of incremental and radical environmental innovation. These findings further our understanding of the environmental collaboration–performance relationship and extend previous research on green supply chain management which previously did not consider the mediating variable (e.g., Zhu and Sarkis, 2004; Vachon and Klassen, 2008). This study highlights that environmental collaboration with suppliers is an effective strategy for an organization to pursue because knowledge-sharing routines enabled through the integration of external resources promote both incremental and radical environmental innovation.

We also find that both incremental and radical environmental innovation significantly improves a firm's operational performance (H4a, b). Porter and Van der Linde (1995a) note that a proactive environmental management strategy can lead to innovation and that the benefits, such as resource productivity, derived from these innovations may offset the cost of implementing environmental management and enable firms to act more competitively. This research presents some empirically insights into Porter and Van der Linde (1995a) concept by focusing on the development of environmental innovation, either incremental or radical, which acts as a mediating variable that helps to explain the relationship between corporate environmental proactivity and a firm's operational performance. Managers should be aware that innovation in the green product development and green process design can contribute to improved operational performance. Environmental innovation could reduce polluting inputs, involve by-products into the recycling processes, and increase the efficiency of production processes. All of these efforts result in the reduction in the costs of input and waste disposal, self-improvement of product quality, delivery and flexibility to meet customer needs about environmental sustainability, and finally lead to improved operational performance.

Furthermore, we distinguish between incremental and radical innovation in green product development and green process design. Both types of environmental innovation can significantly improve a firm's operational performance (H4a, b). Therefore, an organization should focus on developing incremental or radical environmental innovation based on their available internal resources. Incremental innovation might involve less effort and resources (time, financial, or human resource) than radical innovation, and thus if the organization has limited capital and capability, they can choose to make minor improvements or simple adjustments in existing green products and environmental management process to improve operational performance. For organizations with substantive capital and capability, developing radical environmental innovation would be a better choice for them. This is because radical environmental innovation represents fundamental change in environmental products and processes which provide greater environmental benefits to society and thus companies can build the image of a 'green leader' in the market. Additionally, perhaps such a company could charge premium prices when launching radical environmental innovation and thus achieve greater profits. This is similar to the differentiation strategy suggested by Porter (1990). Financial performance of environmental innovation is not the scope of this study, but it could be an interesting future research project.

## 2.7 Conclusion and Future Research

The purpose of this paper is to develop a model how a firm's proactive environmental management strategy influences innovation and operational performance. In doing so, we adopted a strategy-structure-capabilities-performance (SSCP) perspective. This research supports the claim that corporate environmental proactivity is important for a firm's operational performance improvement. It also indicates that environmental collaboration with suppliers and environmental innovation development enhances a firm's ability to improve operational performance. Collaborating with suppliers on environmental management increases incremental and radical environmental innovation and ultimately both types of environmental innovation pay off in terms of reduced production cost, improved quality, delivery and flexibility of the products. Thus companies aspiring to increase environmental innovation and operational performance may need to better align their corporate environmental strategy and the environmental management practice across the supply chain.

While our research has made an important contribution to the literature, there are several opportunities for future research beyond those discussed above. Specifically, this work has implications for increased study of green supply chain management. Green supply chain management has its roots in both the environmental management and supply chain management literatures. Researchers have defined the range of green supply chain management in a variety of ways. Green supply chain management has been treated as a very broad construct including internal, upstream, and downstream entities (Zhu and Sarkis, 2004), a narrower construct that only extends one node away (Vachon and Klassen, 2006), or even narrower, only considering upstream environmental management practices with suppliers (Bowen et al., 2001). Responding to the phenomena, Srivastava (2007) noted that similar to the concept of supply chain management, the boundary of green supply chain management is dependent on the goal of the investigators. In our study, we focus on the impact of environmental collaboration with suppliers. Future research should also examine the broad view of green supply chain management, including internal environmental management, environmental collaboration with suppliers and customers. This would further the understanding of effectiveness of green supply chain management practices on firm performance.

Our findings suggest that a firm's proactive environmental management strategy directly and indirectly improve its operational performance. The process we propose in the model and our findings provide important managerial insights for improving operational performance. Future research should examine if the same process, environmental collaboration with suppliers and environmental innovation development, influences other firm performance variables including financial performance. Future research could make an important contribution as to how green practices also enable a firm to increases its profitability.

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# APPENDIX 2.A: CONSTRUCT ITEMS

| Construct | Label | Items |
|---|---|---|
| Corporate Environmental Proactivity | CEP1 | We always attempt to go beyond basic compliance with laws and regulations on environmental issues |
| | CEP2 | Our corporate management gives a high priority to environmental issue |
| | CEP3 | The top managers in our company give environmental issues a high priority |
| | CEP4 | We lead our industry on environmental issues |
| | CEP5 | We effectively manage the environmental risks which affect our business |
| Environmental Collaboration with Suppliers | EC1 | We collectively work with our suppliers on the achievement of environmental goals. |
| | EC2 | We work together with our suppliers to develop a mutual understanding of responsibilities regarding environmental performance. |
| | EC3 | Our company and suppliers work together to reduce the environmental impact of our activities. |
| | EC4 | We conduct joint planning activities with our suppliers to anticipate and resolve environmental-related problems. |
| | EC5 | We make joint decisions with our suppliers about ways to reduce overall environmental impact of our products. |
| Incremental Environmental Innovation | IEI1 | We often create new patterns of product that are more environmentally friendly |
| | IEI2 | We often improve an existing product to make it more environmentally friendly. |
| | IEI3 | We often exploit existing technologies to make products more environmentally friendly |
| | IEI4 | We often improve existing processes to make them more environmentally friendly |
| | IEI5 | We often exploit existing technologies to make processes more environmentally friendly |
| Radical Environmental Innovation | REI1 | We often create radically new environmentally friendly products |
| | REI2 | We often introduce radically new concept innovations to make products more environmentally friendly. |
| | REI3 | We often introduce radical innovations to make processes more environmentally friendly |
| | REI4 | We often develop and introduce radically new environmentally friendly technologies into the industry |
| | REI5 | We are often the creator of radically new environmentally friendly techniques and technologies |
| Operations performance | OP1 | Implementing environmental innovation has helped improve our manufacturing cost as compared to our competitors |
| | OP2 | Implementing environmental innovation has helped improve our defect rate as compared to our competitors. |
| | OP3 | Implementing environmental innovation has helped improve our delivery speed and reliability as compared to our competitors. |
| | OP4 | Implementing environmental innovation has helped improve our ability to respond to customization requests as compared to our competitors. |

***Table 2.1***: *Descriptive statistics and correlations matrix*

| | Mean | Std. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.Corporate Environmental Proactivity | 5.12 | 1.27 | 1 | | | | | | | | |
| 2.Environmental Collaboration with Suppliers | 3.45 | 1.57 | 0.559** | 1 | | | | | | | |
| 3.Incremental Environmental Innovation | 4.63 | 1.32 | 0.642** | 0.573** | 1 | | | | | | |
| 4.Radical Environmental Innovation | 3.35 | 1.47 | 0.541** | 0.572** | 0.676** | 1 | | | | | |
| 5.Operations Performance | 3.94 | 1.33 | 0.259** | 0.362** | 0.475** | 0.489** | 1 | | | | |
| 6. Firm Size (Log Sales) | 2.90 | 0.947 | 0.300** | 0.287** | 0.331** | 0.282** | 0.213** | 1 | | | |
| 7. HHI | 0.068 | 0.072 | -0.020 | 0.038 | 0.004 | 0.003 | 0.088 | 0.131 | 1 | | |
| 8. R&D stock | 152.56 | 457.33 | 0.162* | 0.184 | 0.229** | 0.222** | 0.041 | 0.432** | - 0.108 | 1 | |
| 9. ROA | -0.0112 | 0.488 | 0.051 | 0.050 | 0.029 | 0.099 | 0.128 | 0.386** | 0.067 | 0.048 | 1 |

*** significant at the 0.01 level; * significant at the 0. 05 level*

**Table 2.2:** Convergent validity and reliability

| Construct | Item code | Standardized Loading | Cronbach's Alpha | Composite Reliability |
|---|---|---|---|---|
| Corporate Environmental Proactivity (CEP) | CEP1 | 0.756 | 0.919 | 0.923 |
| | CEP2 | 0.967 | | |
| | CEP3 | 0.948 | | |
| | CEP4 | 0.782 | | |
| | CEP5[a] | 0.554 | | |
| Environmental Collaboration with Suppliers (EC) | EC1 | 0.962 | 0.970 | 0.981 |
| | EC2 | 0.971 | | |
| | EC3 | 0.973 | | |
| | EC4 | 0.934 | | |
| | EC5 | 0.935 | | |
| Incremental Environmental Innovation (IEI) | IEI1 | 0.955 | 0.951 | 0.984 |
| | IEI2 | 0.980 | | |
| | IEI3 | 0.969 | | |
| | IEI4 | 0.957 | | |
| | IEI5 | 0.946 | | |
| Radical Environmental Innovation (REI) | REI1 | 0.984 | 0.982 | 0.991 |
| | REI2 | 0.982 | | |
| | REI3 | 0.968 | | |
| | REI4 | 0.988 | | |
| | REI5 | 0.975 | | |
| Operations Performance (OP) | OP1 | 0.926 | 0.967 | 0.973 |
| | OP2 | 0.971 | | |
| | OP3 | 0.969 | | |
| | OP4 | 0.933 | | |

*a Deleted from final model*

**Table 2.3.** Discriminant validity test

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1.Corporate Environmental Proactivity | **0.665** | 0.312 | 0.412 | 0.292 | 0.067 |
| 2.Environmental Collaboration with Suppliers | 0.559 | **0.912** | 0.328 | 0.327 | 0.131 |
| 3.Incremental Environmental Innovation | 0.642 | 0.573 | **0.924** | 0.457 | 0.226 |
| 4.Radical Environmental Innovation | 0.541 | 0.572 | 0.676 | **0.959** | 0.240 |
| 5.Operations performance | 0.259 | 0.362 | 0.475 | 0.489 | **0.891** |

*Note: Diagonal entries (in bold) are average variances extracted, entries below the diagonal are correlations, and the entries above the diagonal represent the squared correlations.*

**Table 2.4:** Test of alternative models

| | Hypothesized model (Model 1) | Dropping CEP-OP (Model 2) | Adding EC to OP (Model 3) | Direct model (Model 4) |
|---|---|---|---|---|
| CEP to OP | 0.142** | | 0.152** | 0.310** |
| CEP to EC | 0.382*** | 0.383*** | 0.383*** | |
| EC to IEI | 0.649*** | 0.649*** | 0.649*** | |
| EC to REI | 0.635*** | 0.635*** | 0.634*** | |
| IEI to OP | 0.434*** | 0.409*** | 0.405*** | 0.392*** |
| REI to OP | 0.403*** | 0.386*** | 0.384*** | 0.421*** |
| Firm size to OP | 0.026 | -0.014 | 0.021 | 0.041 |
| Firm profitability to OP | 0.037 | 0.038 | 0.038 | 0.166 |
| R&D expense to OP | -0.069 | -0.067 | -0.070 | 0.000 |
| HHI to OP | 0.028 | 0.031 | 0.024 | 0.704 |
| EC to OP | | | 0.073 | 0.080 |
| | | | | |
| **χ2 difference test** | | | | |
| χ2 | 692.718 | 701.067 | 691.190 | 764.776 |
| Df | 312 | 313 | 311 | 308 |
| χ2/ Df | 2.22 | 2.24 | 2.22 | 2.48 |
| Δχ2(Df) | - | 8.35(1)** | 1.528(1) | - |
| | | | | |
| **Parsimony comparison** | | | | |
| AIC | 850.718 | 861.067 | 855.19 | 934.776 |
| CAIC | 1213.850 | 1215.765 | 1218.755 | 1308.643 |
| PNFI | 0.853 | 0.850 | 0.847 | 0.842 |
| PGFI | 0.790 | 0.786 | 0.776 | 0.768 |

****significant at 0.001 level; **significant at the 0.01 level*

**Table 2.5:** Direct and indirect effects

| Constructs | EC | IEI | REI | OP |
|---|---|---|---|---|
| *CEP* | | | | |
| Total Effect | 0.382*** | 0.248*** | 0.243*** | 0.347*** |
| Direct Effect | 0.382*** | - | - | 0.142** |
| Indirect Effect | - | 0.248*** (0.166, 0.330) | 0.243*** (0.162, 0.323) | 0.205*** (0.133, 0.277) |
| | | | | |
| *EC* | | | | |
| Total Effect | - | 0.649*** | 0.635*** | 0.537*** |
| Direct Effect | - | 0.649*** | 0.635*** | - |
| Indirect Effect | - | - | - | 0.537*** (0.439, 0.635) |
| | | | | |
| *IEI* | | | | |
| Total Effect | - | - | - | 0.434*** |
| Direct Effect | - | - | - | 0.434*** |
| Indirect Effect | - | - | - | - |
| | | | | |
| *REI* | | | | |
| Total Effect | - | - | - | 0.403*** |
| Direct Effect | - | - | - | 0.403*** |
| Indirect Effect | - | - | - | - |

****significant at 0.001 level; **significant at the 0.01 level*
*Note: The numbers in the parentheses are 95% confidence interval based n=5000 bootstrap.*

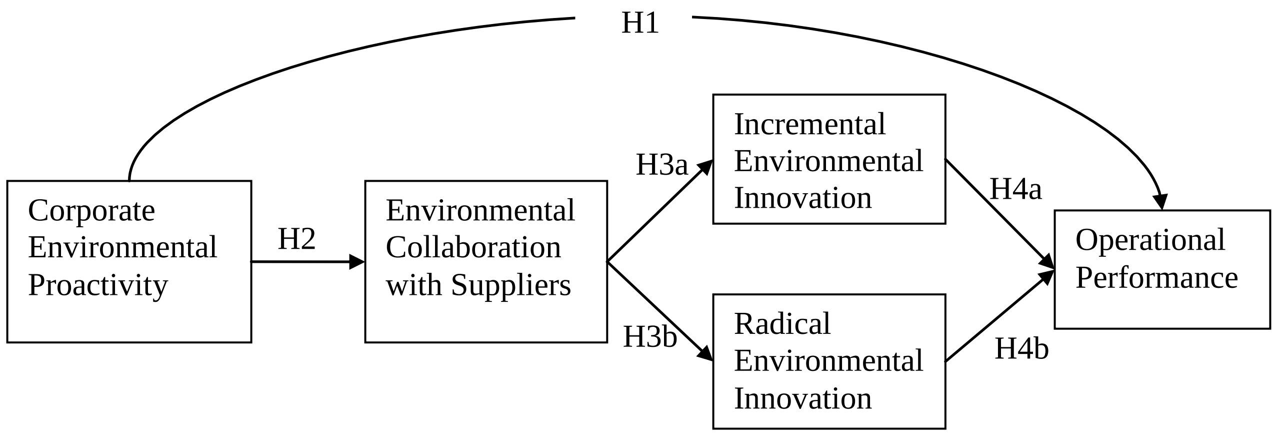


***Figure 2.1:*** *Hypothesized model*

# CHAPTER 3

# AN EXAMINIATION OF HOW A FIRM'S RIVALS AND STAKEHOLDERS INFLUENCE GREEN SUPPLY MANAGEMENT PRACTICES

## 3.1 Introduction

Green supply management is a prominent topic of discussion among supply chain management professionals (Bowen et al., 2001; Mace and Food, 2010; Vachon and Klassen, 2006). Green supply management is defined as the incorporation of environmental considerations into the supply management function and represents one important area where the firm can improve its sustainability footprint. In a supply chain, the supply management function is responsible for monitoring and governing the flow of materials into the firm. A focal firm converts materials from suppliers into value-added products, and thus scholars argue that each organization is only as environmental sustainable as its upstream supply chain partners (e.g. Handfield et al., 2005; Krause et al., 2009; Dai and Blackhurst, 2012). Firms have recognized the need to extend their environmental practices to their suppliers because a supplier's poor environmental management performance can negatively affect the focal firm. Therefore, firms seeking to achieve environmental sustainability goals must actively work with their suppliers (Sharma and Henriques, 2005; Simpson et al., 2007; Tate et al., 2010). An example of the importance of supplier sustainability includes Wal-Mart's supplier sustainability index initiative (Bustillo 2009).

Firms are becoming increasingly pressured by their industry rivals and key stakeholders to pursue environmental management practices (Hofer et al., 2012). Indeed, stakeholder theory and the Schumpeterian view of competition have provided insight into how and why firms pursue several environmental management practices (e.g. Sarkis et al., 2010; Hofer et al., 2012). Yet despite anecdotal and initial academic evidence that stakeholders and a firm's rivals place pressure on the focal firm to implement environmental management practices, the impact of those pressures on green supply management practices remains largely unexplored. Furthermore, scant research exists on how an organization's resources are mobilized in response to rival and stakeholder pressures to implement green supply management practices (Sarkis et al., 2010). Green supply management is often discussed as an effective way to improve an industries' environmental, operational and economic performance (e.g., Carter, Kale, and Grimm, 2000; Vachon and Klassen, 2008; Zhu and Sarkis, 2004). However, despite the potentially important role that green supply management can play in a firm's performance, many organizations have not successfully implemented green supply management practices because of tremendous organizational challenges (Carter and Dresner, 2001; Preuss, 2001; Institute for Supply Management, 2007). For example, green supply management requires organizational structural changes (Lee and Klassen, 2008; Vachon and Klassen, 2008).

In this study, top management support is a critical internal resource that enables an organization to respond to external pressure from rivals and key stakeholders. The important role of top management has been examined in the strategic management, operations management and supply chain literature (Chen and Paulraj, 2004; Jayanth et al., 1999; Swink et al., 2006). Top management support and commitment is touted as a key factor that affects both firm performance and competitive advantage (Jayanth et al., 1999). The upper echelons perspective also suggests that the top management team serves as an organization's primary human interface to stakeholders and rivals and thus top management commitment and support influences organizational decision outcomes (Hambrick and Mason, 1984). Stated differently, a firm's top management team has the authority to make strategic decisions including directing organizational resources that are necessary to respond to external pressures from rivals and stakeholders (Carter, 2004; Liang et al., 2007). However, how the firm's top management mobilizes the organization to implement green supply management practices is not widely understood and previous environmental management literature provides limited insights (Gattiker and Carter, 2010). Given the importance of the top management team in the operations management and similar disciplines, more research is needed to understand the role of top management support of environmental management practices (Gattiker and Carter, 2010).

Drawing upon the insights from stakeholder theory, the Schumpeterian view of competition and top management literature, this study examines the effect of top management support in response to rival and stakeholder pressures to implement green supply management practices. The Schumpeterian economics view of competition and stakeholder theory are combined to explain the role that the external environment has on how a firm responds to sustainability pressures. Our study also integrates previous top management literature to examine the role of top management support in motivating organizations to implement green supply management practices.

This study extends and complements previous green supply chain management research in several important ways (e.g. Gattiker and Carter, 2010; Hofer et al., 2012; Sarkis et al., 2010; Zhu and Sarkis, 2004). First, recognizing that there are different pressures to drive the implementation of green supply management, we incorporate stakeholder theory and the Schumpeterian view of competition together to develop our model. Second, to further the understanding of the role of top management support for green supply management, we investigate how stakeholder pressure and rival pressure influence the implementation of green supply management through the marshalling of top management support of environmental management activities. External green pressures will first affect the attitudes of top managers who will then marshal internal resources directed towards green supply activities (Liang et al., 2007). Thus, we argue that stakeholder pressure and rival pressure affect the implementation of green supply management through key organizational members (i.e., top management). Third, we provide empirical evidence for the role of top management support in implementing green supply management practices. It is important for top management to prioritize how an organization responds to external pressures to act in a sustainable way. Finally, we identify key dimensions of green supply management practices from the literature and propose a conceptual model for analyzing the drivers and enablers of green supply management implementation. By developing a grounded model that combines the impact of green supply management determinants and organizational factors on green supply management, this study responds to the call for future research to further our understanding of the determinants of the implementation of green supply management (Carter and Carter, 1998; Schoenherr et al., 2012).

The next section reviews the literature and explains the research model. As we then describe, the model is tested using survey data collected from supply chain management professionals. Finally, we discuss the study's results and contributions.

## 3.2. Literature Review

### 3.2.1 Antecedents of environmental management

There is an increasing amount of interest in examining the antecedents of sustainability including green supply management in the field of operations management (Angell and Klassen 1999; Kleindorfer et al. 2005). Multiple theoretical perspectives are introduced to explain why companies pursue green issues in supply chain management. Stakeholder pressure is frequently proposed as an important external driver of environmental management implementation (e.g., Delmas, 2001; Delmas et al., 2008; Sarkis et al., 2010). Specifically, empirical studies provide evidence that stakeholders pressure the firm to implement environmentally oriented reverse logistics (Sarkis et al., 2010), green logistics practices (González-Benito and González-Benito, 2006) and ISO 14001 (Delmas, 2001). Stakeholders primarily include workers, clients/customers, government, shareholders and nongovernmental organizations, as well as the community (Sarkis et al., 2010). Recently, researchers have begun to consider how competitors impact the adoption of environmental management practices. Corbett (2006) noted that a competitor's action is a motivating factor in the adoption of ISO 9000, but he didn't test the findings for ISO 14000. Based on the Schumpeterian view of competition, Hofer et al. (2012) investigate competitive interactions among leader and challenger firms in the domain of environmental management and provides empirical evidence that a rival's past environmental activity has significant impact on a focal firm's environmental management activity. Thus the above mentioned research, among several other studies, shows that companies understand the importance of responding to pressure from stakeholders and competitors to improve their position in the marketplace. Yet empirical studies on the competitive determinants of environmental management are still limited and thus more research is needed (Hofer et al., 2012). Moreover, scant research has examined how stakeholder theory and the Schumpeterian view of competition together serve as an explanatory theoretical lens for explaining what drives the adoption of green supply management practices within the boundaries of the firm. Sarkis et al., (2010) and Sarkis et al. (2011) note that it is important to apply multiple theoretical perspectives in a single study in order to further our understanding of drivers of green supply management. This study seeks to respond to the Sarkis et al., (2010) and Sarkis et al. (2011) studies by drawing from stakeholder theory and the Schumpeterian view of competition to explain the external factors that motivate a firm to implementation green supply management practices.

To respond to environmental management pressures from stakeholders and rivals, companies need to mobilize internal resources and capabilities. Examples of important internal human resource practices for responding to external pressures for the firm to pursue environmental management practices include communication and training practices (Chinander, 2001; Sarkis et al., 2010), project championship for environmental projects (Gattiker and Carter, 2010), and supply chain management employee commitment (Cantor et al., 2012). Top management support is another important practice that has been recognized in the environmental management literature (e.g. Drumwright, 1994; Carter and Jennings, 2004; Pagell and Wu, 2009). However, the role of top management support to manage and respond to external pressures from stakeholders and competitors toward environmental management has not been thoroughly examined (Gattiker and Carter, 2010). This study contributes to existing literature by examining the role of top management support in linking stakeholder pressure and competitive pressure from rivals to the adoption of green supply management.

**3.2.2 Green supply management**

The focus of our research is on green supply management because we recognize the vital importance that this practice serves in a firm's quest to improve its environmental performance. Based upon a review of existing green supply management literature in operations management field (see Table 3.1) and discussions with practitioners, we identify key dimensions of green supply management. The practices and activities that collectively define green supply management can be categorized along three different dimensions: monitoring suppliers' environmental performance, collaborative planning with suppliers on environmental issues, and involvement of suppliers in environmental-friendly product development (e.g., Vachon and Klassen 2006; Zhu and Sarkis, 2004). This study is among the first research investigations that addresses this gap in the green supply management practices literature (Schoenherr et al., 2012).

### 3.3 Theoretical Framework and Research Model

To examine how rival and stakeholder pressure influence top management support of green supply activity, our research builds on insights from stakeholder theory, the Schumpeterian view of competition, and top management literature. In recent years, stakeholder theory (Freeman, 1984) has emerged as a powerful explanation to account for the influence of stakeholder groups on organizational decision making and outcomes. As posited by stakeholder theory, stakeholder pressure results in significant motivation for companies to implement environmental practices (Buysse and Verbeke, 2003; Sarkis et al., 2010).

Our study also integrates the Schumpeterian view of competition as an important theoretical lens. The Schumpeterian view has been previously adopted to explain how and why firms engage in competitive moves and counter moves (Young et al., 1996). The Schumpeterian view of competition is based on the contention that competitive actions trigger competitive responses by rivals (Schumpeter, 1934, 1942). Based on the Schumpeterian view of competition, researchers have examined the extent to which firms implement environmental management activities in response to their rivals' environmental management efforts (Hofer et al., 2012). Combining stakeholder theory and the Schumpeterian view of competition, we provide a deeper understanding about the external green supply management pressures posed on the firm.

Our study also draws upon the top management literature including upper echelons theory. The top management team is responsible for making the organizational decisions to respond to changes in the external environment (Liang et al., 2007). According to upper echelons theory in the top management literature, executives can act both proactively and reactively (Child, 1997) and thereby exercise decision-making authority to real or perceived external expectations (Child, 1972; Hitt and Tyler, 1991; Hrebiniak and Joyce, 1985; Oliver, 1991). The top management literature further suggests that top management support facilitates the provision of adequate financial and human resources to direct organizational actions (Colbert, 2004; Swink, 2003). Thus, we argue that stakeholder pressure and competitive pressure from rivals affect the adoption of green supply management practices through key organizational members (top management). Our theoretical framework is grounded in the proposition that stakeholder pressure and competitive pressure from rivals affect three dimensions of green supply management through the mediating role of top management support (see Figure 3.1).

**3.3.1 Rival pressure and top management support**

The first important factor that we examine in our model is the role that pressure from rivals places on top management support of environmental management activities. We draw on the Schumpeterian view of competition to examine how firms are now competing in the environmental management domain. A company's market orientation always includes continuous and close observation of its competitors' activities and strategies which are central elements of the market environment (Narver and Slater, 1990). According to the Schumpeterian view of competition, firms can attain competitive advantage over time by taking action (Jacobson, 1992). Actions often provoke reactions, thus competitive advantages are created in the context of action and reaction (Grimm et al., 2005). Environmental management activities are a type of action that firms can implement to gain a source of competitive advantage (Schmidheiny, 1992; Shrivastava, 1995a, b; Hart 1995). For example, Apple Corporation only began to reveal the amount of carbon emissions associated with the manufacture and use of its products when it discovered that the lack of environmental disclosure, especially relative to its competitor Dell, hurt the company as reflected in its poor environmental ratings (Engardio et al., 2007). At the same time, Apple announced that it was ending the use of environmentally problematic materials such as polyvinyl chlorides (PVCs) and bromide flame retardants (BFRs) in its devices. This announcement put Apple well ahead of its rival Dell, which had previously set the same goal but had not yet achieved it (Burrows, 2009). Recent empirical research also has examined the extent to which leader and challenger firms implement environmental management activities in response to their rivals' environmental management efforts (e.g., Hofer et al., 2012).

While firms certainly monitor competitor behavior and react accordingly, it would be difficult to successfully implement those actions without the support from top management (Schneider and Wallenburg, 2012). When top management receives signals that rivals are engaged in green activities and even achieve competitive advantage from green activities, the focal firm responds (Hofer et al., 2012). Based on their experience and personal characteristics, top management would make judgments on the competitor behaviors and then direct resources within the firm to pursue environmental management activities. Top-level managers have a better understanding of the firm's resources that can be utilized to remain competitive in the marketplace (Hahn et al., 1990). Usually, the top manager would follow or mimic those actions that have seemingly resulted in success in other organizations (Haunschild and Miner, 1997; Ketokivi and Schroeder, 2004). Since the performance of environmental management on firm financial performance is not clear (Jacobs et al., 2010), to deal with this uncertainty, top management would provide support for the environmental initiatives when they observe their competitors have achieved success from the implementation of environmental management. Thus we argue:

***H1:*** The greater a rival derives benefits from environmental management practices, the greater the top management support for environmental initiatives.

**3.3.2 Stakeholder pressure and top management support**

The second important factor that we examine in our model is the role that stakeholder pressure places on top management support of environmental management activities. Since resource interdependence is a foundation of stakeholder theory (Pfeffer and Salancik, 1978) and resource interdependence exists between the focal firm and its stakeholders, researchers have noted that stakeholders can influence an organization's decision-making using various strategies (Frooman, 1999). Companies understand the importance of responding to pressure from stakeholders (Freeman, 1984) to help improve their competitive posture and thus when top management perceives strong stakeholder demand for environmental management, top management would participate in and support environmental initiatives.

Key stakeholders mainly include employees, clients/customers, government, shareholders, and nongovernmental organizations and the community (Sarkis et al., 2010). More specifically, employees are internal stakeholders who can initiate the firm's pursuit of environmental management activities (Cantor et al., 2012; Daily and Huang, 2001; Hanna et al., 2000). To be able to recruit and retain a talented workforce who have a strong preference for working in firms with a proactive environmental management orientation, top management must create a culture that demonstrates environmental management considerations are valued at the firm (Reinhardt, 1999). This suggests that top management will provide support toward environmental initiatives to address internal stakeholder (employee) environmental pressure.

A number of external stakeholder groups including government officials, shareholders, customers and society, also influence top management support of environmental management practices. Companies could face the threat of regulation, legal action, penalties, and fines if they don't comply with environmental regulation. In contrast, if the firm is supportive of environmental management activities, the firm may build political capital and a good reputation with governmental entities (Hoffman, 2000; Sarkis, et al., 2012). Society (e.g., environmental organizations, the media and community) is also an important stakeholder that could mobilize public opinion and impact a firm's public image and thus it is a critical factor that influences top management's decision to support environmental practices (Gunningham et al., 2004). The power and urgency of customers also explain why customer initiatives have been identified repeatedly as an important driver for implementing environmental management (Carter and Carter, 1998; Carter and Dresner, 2001; Carter and Jennings, 2004; Lee and Klassen, 2008; Zhu and Sarkis, 2004). Consequently, top management would provide great support to fulfill the customer expectations for positive environmental management actions. As for shareholders who have made financial investments in the firm, the firm must respond to these stakeholders by maximizing their value (Reinhardt et al., 2008). Evidence exists that environmental management provides companies with a 'win-win' situation –improvement on both environmental performance and firm financial performance. Thus, top management support toward environmental management serves to address shareholder pressure. Thus we argue:

***H2:*** The greater the stakeholder pressure to implement environmental management, the greater the top management support for environmental initiatives.

**3.3.3 Top management support and implementation of green supply management practices**

Top management is a key driver of an organization's strategic programs and initiatives (Mintzberg, 1973). Top management support, leadership, and commitment to change are important antecedents to the implementation of supply chain management activities and programs (Lambert et al., 1998). The human resource management perspective in the top management literature suggests that top management influences the creation of organizational values and develops suitable management styles to direct organization choice and improve the firm's performance (Hambrick and Mason, 1984). According to upper echelons theory (Hambrick and Mason, 1984), the organization's culture and values are a reflection of top management. The commitment of top management is particularly important because top management has the status necessary to influence organizational actions (Finkelstein and Hambrick, 1990, 1996). To completely embrace environmental excellence, top management must be highly committed (Zsidisin and Siferd, 2001). Top management's boundary spanning role has been found to significantly affect environmental projects by gaining employees' commitment (Gattiker and Carter, 2010). Examples set by top company management have the potential to impact an employee's actions in the ethically uncertain and ambiguous areas that may not be clearly outlined by company policy (Carter and Jennings, 2004). In fact, lack of top management support is a major reason for the failure of environmental management practices (Hillary, 2004). We propose that executives who are strongly committed to environmental management will influence their organizations to develop green supply management.

Green supply management involves monitoring and assessment of suppliers, which act as a way to build control mechanisms to assess environmental performance including legal compliance and to mitigate the possible environmental risk from supplier fault (Klassen and Vachon, 2003). To be able to effectively monitor suppliers, high level policy and values statements should be in place. Many environmental evaluation activities are based on pre-established performance standards for the quality of the materials and suppliers' internal environmental management (Leenders and Fearon, 1997). Support from top management would also motivate supplier awards and feedback which are important for the suppliers' environmental performance development (Krause et al., 2000)

Involving suppliers in environmental-friendly product development activities is another important dimension of green supply management. Previous literature has proposed that the capability of suppliers plays an important role in a firm's ability to engage in innovation and new product development (Swink and Mabert, 2000; Song and Di Benedetto, 2008). Involving suppliers in environmentally friendly product development helps the firm in identifying potential technical problems such as contradictory specifications or unrealistic designs, early in the design-for-environment process and thus speeds up green product development and responses to market demands (Kessler and Chakrabarti, 1996). Top management commitment and support is one important way to overcome the barriers to supplier involvement on new product development (Ragatz et al., 1997; Primo and Amundson, 2002). Visible top management support also motivates employees to work with suppliers on environmental-friendly product development projects (Swink, 2003).

Green supply management also involves collaborative planning with suppliers on environmental issues (i.e., collaboration with suppliers in planning jointly for environmental management and environmental solutions) (Vachon and Klassen, 2008). Collaborative planning with supplier activities requires strong communication, training and assistance in order to achieve mutual understanding on environmental issues. Top management support is needed for building and nurturing this trustful and cooperative relationship. It is difficult to build and nurture the same kind of thinking throughout the organization unless support for environmental management initiatives is provided by senior management (Lockstrom, et al., 2010). Without top management support to build the right strategic orientation and develop a trust in buyer–supplier relationship, it is not possible to develop and maintain the required organizational resources and commitment necessary for successful implementation of green supply practices. Thus, we argue:

***H3a*****:** The greater the top management support of environmental initiatives, the greater the firm monitors supplier's environmental performance.

***H3b*****:** The greater the top management support of environmental initiatives, the greater the firm involves suppliers in environmentally friendly product development activities.

***H3c*****:** The greater the top management support of environmental initiatives, the greater the firm engages in collaborative planning with suppliers on environmental issues.

## 3.4 Methodology

### 3.4.1 Survey development and sample

To study our hypothesized relationships, a survey instrument was developed by following the procedures and guidelines recommended by Churchill (1979), Gerbing and Anderson (1988), and Dillman (2000). The design process for the questionnaire consisted of two stages. In the first stage, we conducted an extensive review of the literature to assist with identifying the constructs in the model. Established measures were adopted directly or modified slightly to measure each of the constructs. This process involved making word and sentence changes so that all items fit this research context. In the second stage, the preliminary draft questionnaire was reviewed by seventeen industry practitioners (mid- or senior-level supply chain managers) and MBA students for ambiguity, readability, and clarity purposes. Two SCM professors and four

PhD students reviewed the survey for item specificity, face validity and content validity. The questionnaire was revised based on feedback from both practitioners and academics.

To ensure data confidentiality, the web-based survey was administered by a large public US university. Following the recommendations of Dillman (2000) and because of the potential for a low survey response rate, we notified in advance 3,490 potential supply chain professional respondents by phone about our survey. In so doing, we hired and trained undergraduate and graduate students to telephone the potential survey respondents from a telephone and email mailing list acquired from the Dun and Bradstreet (D&B) Company. As described by Dillman (2000), pre-notifying potential survey respondents helps to improve survey response rates. Moreover, survey respondents were motivated to participate in this study because the subject matter of our questionnaire is viewed as a current topic that could impact the key informant's profession. After calling potential survey respondents, our student research assistants emailed the D&B contacts with a link of the online questionnaire along with a brief explanation which described the study's objectives. Our student research assistants also made follow-up telephone calls and sent reminder emails about our study as suggested by Dillman (2000). Additionally, to encourage participation in the research project, we offered a summary of the results to the survey respondents (Dillman, 2000).

The population for the survey was drawn from supply chain management professionals who are employed by publicly traded firms in the United States as reflected in the D&B database. Of those respondents that we were able to contact by telephone, 197 respondents formally declined to participate in the survey because of company policy, other time commitments, or lack of interest in the survey topic. 1,425 respondents were no longer employed by their organization. 419 potential professional contacts were not reachable by telephone or voicemail because of either bad email addresses or the phone numbers derived from the D&B database were no longer in service. A total of 1,449 potential respondents received an emailed link to the survey. We received 264 responses. After excluding 34 incomplete survey responses, 230 useable observations were retained out of 1,449 contacts, resulting in a response rate of approximately 16% (230/1,449).

Demographic data is shown in Table 3.2. Over eighty percent (81.3%) of the respondents are from manufacturing industries. Seventy-six percent of the survey respondents hold the position of a manager or higher. About ninety-five percent of the survey respondents have more than ten years of work experience. On average, the key informant worked for a company where total sales are approximately $5.9 billion.

**3.4.2 Non-response bias**

In this study, non-response bias was assessed using two approaches. First, the responses of early and late responses were compared (Lambert and Harrington, 1990; Armstrong and Overton, 1977). The firm demographic variables were included in this analysis. The t-tests performed on the responses of these two groups yielded no statistically significant differences at the 99% confidence interval across several variables, including job position, work experience, industry type, respondent age and gender. As a second test of non-response bias, we randomly selected 300 companies from the list of firms that did not participate in our study. We collected firm size information to assess non-response bias (i.e., number of employees as well as sales volume). This information was combined with the firms that did participate in our study. The sample and the population means of the firm size variables were compared for any significant difference. The t-tests performed yielded no statistically significant differences at the 99% confidence interval between the sample and population. These results suggest that non-response does not appear to be a serious problem.

**3.4.3 Constructs in the model**

The variables used in this study are based on well-established items in the operations management literature. A complete list of the items used is provided in Appendix 3.A.

Our key independent variable, rival pressure, is derived from Liu et al (2010). The construct describes the extent that the focal firm's main competitor has obtained a competitive advantage in the marketplace by implementing environmental management. Respondents were asked to rate each item on this construct using a seven-point response format (1=very low; 7=very extensive). Another key independent variable, stakeholder pressure, is derived from Sarkis et al (2010). To measure stakeholder pressure, we asked survey respondents to indicate the extent they felt pressure to implement environmental management from five stakeholder groups (customers, government, shareholders, employees and NGOs/society). Respondents rated each stakeholder on a five point scale from 1 (not at all) to 5 (very strongly). Our measure of top management support is derived from Carter and Jennings (2004) and Gattiker and Carter (2010). The construct describes the extent that top management motivates environmental initiatives.

Respondents were asked to rate each item using a seven-point response format (1=very low; 7=very extensive). Next, we examined the extent to which a firm implements green supply management. Green supply management consists of three dimensions: monitoring suppliers' environmental performance, involvement of suppliers in environmental-friendly product development and collaborative planning with suppliers on environmental issues. The measurement items for each dimension are described below. We measured monitoring suppliers' environmental performance based on items developed by Vachon and Klassen (2006). Respondents were asked to rate each item on a seven-point response format (1=very low; 7=very extensive). Our measures of involvement of suppliers in environmental-friendly product development are derived from Mishra and Shah (2009). Respondents were asked to respond to the supply chain collaboration for green product development using a seven-point response format (1=very low; 7=very extensive). We measured collaborative planning with suppliers on environmental issues based on items developed by Vachon and Klassen (2006). Respondents were asked to rate each item on a seven-point response format (1=very low; 7=very extensive). Additionally, we used firm size as a control variable in our model. We controlled for the size of the firm as larger firms tend to have access to more resources than smaller firms to implement environmental management with suppliers. We expect that larger firms would be more likely to implement green supply practice. Firm size is measured by total sales. The firm size data was derived from the Compustat database. Because this variable is skewed, we log transformed this variable.

## 3.5 Analysis and Results

We examined the reliability and validity of our constructs. In particular, we adopted Gerbing and Anderson's (1988) two-step approach, which consists of first examining the measurement model and then the structural model to analyze the data. We assessed the measurement model, including convergent validity, discriminant validity and common method bias, in order to assure that the measures used in the analysis was reliable and valid. Table 3.3 presents descriptive information on each variable and the correlations across constructs.

### 3.5.1 Measurement Instrument Validation

Construct validity is the extent to which the items on a scale measure the abstract or theoretical construct (Churchill, 1979). Testing of construct validity concentrates not only on finding out whether an item loads significantly on the factor (i.e., convergent validity) but also on ensuring that it measures no other factors (i.e., discriminant validity) (Campbell and Fiske, 1959). Convergent validity exists if a group of indicators are measuring one common factor. Convergent validity is demonstrated by the statistical significance of the loadings at a given alpha (e.g., $p = 0.05$). A loading of 0.7 indicates that about one-half of the item's variance (the squared loading) can be attributed to the construct, thus, 0.7 is the suggested minimum level for item loadings on established scales (Fornell and Larcker, 1981). Composite reliability and average variance extracted were calculated using the procedures suggested by Fornell and Larcker (1981). Composite reliability (CR) for each construct is above 0.70, and average variance extracted is 0.56 or greater. Cronbach alpha values of all factors are well above 0.80. Table 3.4 provides all these values and suggests sufficient convergent validity.

Discriminant validity among the constructs was assessed by first evaluating whether the intercorrelation among the constructs is less than .70 which suggests the constructs have less than half their variance in common (Hair et al., 2010). All pairs of constructs meet this threshold. Also discriminant validity was assessed by comparing the average variance extracted (AVE) for each construct with the square of the correlation between all possible pairs of constructs (Hair et al., 2010). In all cases, the AVE is greater than the square of the correlation between all possible pairs of constructs (Table 3.5). Overall, the results offer support for discriminant validity among the constructs.

### 3.5.2 Common Method Bias

Our study employed multiple methods to mitigate potential effects of common method bias. First, we surveyed the top managers of each firm who are knowledgeable about their operations. Survey responses from high level managers are recognized to be reliable sources of information and hence minimize the potential of common method bias (Miller and Roth, 1994; Narayanan et al., 2011). Second, a reversed coded item is included in our survey design (Podsakoff et al., 2003). Third, we performed Harman's single factor test for survey data using a confirmatory approach in order to assess the degree of common method bias in the data ($\chi2$=3168.312, Dof=350, p=0.00, CFI=0.595, TLI=0.563 and RMSEA=0.187). Our Harmon's single factor test results are considerably worse than those of the measurement model ($\chi2$=609.111, Dof=330, p=0.00, CFI=0.960, TLI=0.954 and RMSEA=0.061). This suggests that a single factor is not acceptable, thus further suggesting that common method bias is not a concern. Fourth, to further assess common method bias, we tested a measurement model having only the traits (trait-only model) first and then added a single method factor to the trait-only model (Widaman, 1985; Podsakoff, et al., 2003; Cao and Zhang, 2011; Zacharia et al., 2011). The results of this test indicate that the added method factor only accounts for 4.6% of the total variance, which is below the 10% threshold suggested by Paulraj, Lado, and Chen (2008). Also, the item loadings for their factors are still significant even when the method factor is included in the model. Finally, following the approach recommended by Lindell and Whitney (2001), we checked for the impact of method variance by using the lowest bi-variate correlation among the manifest variables as the marker variable. We computed the adjusted correlation matrix and tested the significance of the adjusted correlations. All correlations remain significant after the adjustment. Lindell and Whitney (2001, p. 118) state that "if any zero-order correlations that were statistically significant remain significant, this suggests that the results cannot be accounted for by CMV." Based on the above findings, it is reasonable to conclude that common method bias is not a serious concern.

### 3.5.3 Hypotheses Testing

Next, we tested our hypotheses using structural equation modeling. The fit indices of our measurement model meet the cut-off values suggested by Hu and Bentler (1999) ($\chi 2$= 633.463, Dof=339, p=0.00, $\chi 2$/Dof=1.87, CFI=0.958, TLI=0.953, and RMSEA=0.061).

All hypotheses are supported (figure 3.2). As expected, rival pressure is positively related (β=0.266, p<.001) to a firm's top management support for environmental initiatives (H1). Stakeholder pressure for environmental management is also positively related (β=0.245, p<.01) to a firm's top management support for environmental initiatives (H2). Top management support for environmental initiatives has a positive significant impact on monitoring suppliers' environmental performance (β=0.255, p<0.001), involvement of suppliers in environmental-friendly product development (β=0.222, p<0.01), and collaborative planning with suppliers on environmental issues (β=0.229, p<0.01). Thus H3a, H3b, and H3c are supported. The control variable of firm size has positive and significant effect on monitoring suppliers' environmental performance (β=0.150, p<0.05) and collaborative planning with suppliers on environmental issues (β=0.184, p<0.01), but does not have a significant effect on involving suppliers on environmental-friendly product development (β=0.094, p=0.154). We will discuss the implications of our findings in the discussion section.

**3.5.4 Mediation Analysis**

Our model suggests that top management support on environmental initiatives fully mediates the relationship between pressures on environmental management from stakeholders and rivals on the implementation of green practices with suppliers. To assess the mediation effect we conducted two additional statistical tests. First, we followed Baron and Kenny (1986) which has also been used in the environmental management literature (Sarkis et al. 2010). To evaluate mediation, we propose two SEM models. The first model (M1) focuses on the direct relationship between the dependent (green supply management) and independent variables (rival pressure and stakeholder pressure), while the second model (M2) incorporates the mediating top management support factor. As stated by the results listed in Table 3.6, in M1, the independent variables (rival pressure and stakeholder pressure) have a positive and statistically significant influence on the dependent variables (three dimensions of green supply management). In M2, the independent variables (rival pressure and stakeholder pressure) significantly impact the mediator (top management support), and the mediator also significantly affects the dependent variables (three dimensions of green supply management) in a positive way. Additionally, the effect of the independent variable on the dependent variable is diminished after controlling for the effects of the mediator. The results satisfy all conditions suggested in Baron and Kenny (1986), thus the mediation role of top management support on environmental management is confirmed.

Second, we conducted an indirect effect analysis with bootstrapping. Recent studies suggest significant indirect effects from the Sobel test provide evidence for mediation (MacKinnon et al., 2002; Shrout and Bolger, 2002). All indirect effects are significant at the p=0.05 level (Table 3.7). Given the 'power' issue in the Sobel test (Kenny, 2012), we further used the bootstrap approach (n=5000) to evaluate the statistical significance of the indirect effect. All indirect effects are significant using a 95% confidence interval (Table 3.7). These results further indicate the mediation effect of top management support for environmental initiatives exists in our model.

## 3.6 Discussion and Conclusion

This study offers empirical support for the role of top management support in linking rival pressure, stakeholder pressure and three dimensions of green supply management implementation. The results of this study indicate that rival pressure and stakeholder pressure influence green supply management implementation through the important role of top management support of environmental management practices. This study also presents evidence of complete mediation. These results show that companies are implementing green supply management when top management provides support and commitment to environmental management practices. Top management support is seen as necessary for the organization to secure important resources and to provide leadership in uncertain circumstances (Chen and Paulraj, 2004). Thus, obtaining and maintaining top management support is required in order to achieve effective response to rival pressure and stakeholder pressure. In so doing, our study addresses the recent call for studies that advance green supply management research (Schoenherr et al., 2012). Below, we summarize the contribution of our research to theory and practice. We also provide a discussion of areas for future green strategy research.

### 3.6.1 Theoretical and managerial implications

The current research enriches green supply chain management research by examining how rival pressure and stakeholder pressure affect a firm's green supply management through top management support. Using a multi-disciplinary approach, our research builds on insights from stakeholder theory, upper echelons perspective, and the Schumpeterian view of competition. These complementary theories increase our understanding on how firms adopt green supply management to respond to pressures from stakeholders and rivals. The Schumpeterian view of competition and stakeholder theory are used in this study to recognize that firms perceive not only stakeholder demand for environmental management but also the pressure from rivals who achieved competitive advantage through implementation of green practices. Upper echelons perspective and the top management literature are integrated into this study to explain the leadership role that top management serves in the management of the organization's response to dynamic changes in the external environment. A study of multiple theoretical perspectives furthers our understanding of how theories from the environmental, operations management and strategic management literature can be used in tandem to illustrate how the firm responds to competitive environmental pressures. In this study we have shown how this multi-theoretical framework is valuable to explain the important role of top management support in firms' adoption of green supply management.

The application of the Schumpeterian view of competition and stakeholder theory together in the green supply chain management literature is scarce. Researchers have realized that stakeholder pressure (e.g., Sarkis et al., 2010) or a competitor's green supply chain actions (e.g. Hofer et al., 2012) can motivate a focal firm's adoption of environmental practices, but the relative power of these environmental pressures have not been previously investigated. The results in our study show that both competitive pressure and stakeholder pressure have a statistically significant and positive impact on top management support for environmental initiatives, thus providing support for

Hypotheses 1 and 2. Firms undertake new organizational actions when the firm faces external pressure to do so. Not only stakeholder pressure for legitimation exists in our setting, but also firms search for economic efficiency by engaging in those strategic environmental actions that have resulted in success among other organizations (Haunschild and Miner, 1997; Ketokivi and Schroeder, 2004). Our results suggest that this interplay exists among the sample of our firms.

Top management support for environmental management has received a steady amount of increased research interest. In our study we utilize upper echelons theory to show that top management is the interface between the external business environment and the internal organizational actions. A key implication is that top management should constantly monitor and evaluate how rivals and stakeholders perceive the importance of a firm's green supply management practices and respond accordingly. Indeed, our study provides empirical evidence that top managers' support of environmental initiatives is positively associated with implementation of green supply management. Thus, we present support of Hypotheses H3a, b and c. Future research could examine the characteristics of top management teams and how the executive team's background in environmental management activities influences their green supply management strategies.

Our study also contributes to the literature by providing a systematic study of green supply management. We identified key dimensions of green supply management through a review of the literature. These three identified dimensions suggest that green supply practices are implemented at different organizational levels – monitoring suppliers' environmental performance (tactical), involving suppliers in environmental friendly product development (operational) and collaborative planning with suppliers on environmental issues (strategic). Environmental consideration exists not only at the tactical or operational supply chain levels but also at the strategic level which is critical to improving the long-term orientation of the firm (Montabon et al., 2007). In so doing, our study builds-upon prior rigorous academic research by continuing to examine green supply management in a systematic way which is consistent with the recommendations of Schoenherr et al. (2012).

The findings of our study suggest that external forces such as competitive pressure and stakeholder pressure influence organizations to initiate a broad range of green supply management practices such as monitoring and evaluation, green product development and collaborative planning. But much of the guidance for how green supply management practices are implemented comes from a firm's top managers and their commitment to environmental management. Thus, a firm's green strategic focus must be viewed as an important influence on an organization's environmental structures and practices. Our findings highlight the importance of how managers must take an active role in promoting green supply chain management among its supply base. In essence, as a part of their leadership role, managers should offer clear expectation for evaluating and developing its green supply base.

The results of our firm size control variable offer practical implications. From a Schumpeterian perspective, large firms usually have more resources and power to dedicate to firm moves and counter moves. These firms have the organizational resources and slack to counter the competitive actions of rival firms. These firms also have more sophisticated supplier evaluation and development programs including environmental management practices. Walmart is a good example. Walmart launched an ambitious supplier sustainability index project in order to promote the importance of environmental considerations across their supplier network. Our results show that firm size is an important predictor on two of our supplier factors – monitoring and collaborative planning. However, our results show that firm size has no significant impact on the supplier involvement on environmental-friendly product development but with positive direction. The potential explanation is that 'green' has become an important marketing strategy to obtain positive gains (Luo and Bhattacharya, 2006). More and more organizations recognize the importance of developing environmental-friendly products. As a result, to compete in the market, managers, especially in small and medium sized firms, should nurture an organization that fosters an innovative culture to involve suppliers to redesign products to reduce material content and energy consumption and even develop new green products.

**3.6.2 Future research**

There are several opportunities for future research. First, our sample is based on publicly traded US companies and thus future research should examine our model in other contexts. Future research should investigate whether our factors are important in other countries and among non-publically traded companies. Cultural differences and the economic development status of the country where the firm operates could provide interesting insights.

Our study confirmed the positive impact of top management support on green supply management practices adoption. Future studies could examine how top management support influences the implementation process of green supply practices. Future research could also explore the role top management support plays between the relationship between green supply practices and firm performance, including environmental, operational and financial performances.

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# APPENDIX 3.A: CONSTRUCT ITEMS AND THEIR SOURCES

| Construct | Label | Items | Reference |
|---|---|---|---|
| Stakeholder pressure | STA1 | Customers | Sarkis, et al. (2010) |
| | STA2 | Government | |
| | STA 3 | Shareholders | |
| | STA4 | Environmental Organization/Society | |
| | STA5 | Employees | |
| Competitive Pressure (Rival Pressure) | COM1 | Our main competitors that have implemented environmental management benefited greatly. | Liu, et al. (2010) |
| | COM2 | Our main competitors that have implemented environmental management are perceived favorably by customers. | |
| | COM3 | Our main competitors that have implemented environmental management became more competitive. | |
| Top management support for environmental initiatives | TOP1 | Environmental initiatives are motivated by the examples top management provides. | Carter and Jennings (2004); Gattoker and Carter (2010) |
| | TOP2 | Environmental initiatives are motivated by requirements made from senior management. | |
| | TOP3 | Environmental initiatives are motivated by people at the top of our firm. | |
| Monitoring suppliers' environmental performance | MON1 | We select suppliers in part based on the environmental performance factors. | Vachon and Klassen (2006) |
| | MON2 | We notify our suppliers of our environmental sourcing requirements. | |
| | MON3 | We send environmental questionnaires to suppliers in order to monitor their compliance. | |
| | MON4 | We require that our suppliers have an implemented environmental management system (e.g. ISO 14000). | |
| | MON5 | We ask our suppliers to commit to waste reduction goals. | |
| | MON6 | We monitor our supplier's compliance to our environmental sourcing requirements | |
| Involvement of suppliers in environmental-friendly product development | INV1 | Suppliers were involved early in the design of environmentally-friendly products. | Mishra and Shah (2009) |
| | INV2 | We partnered with suppliers for the design of environmentally-friendly products. | |
| | INV3 | Suppliers were frequently consulted about the design of environmentally-friendly products. | |
| | INV4 | Suppliers were an integral part of the design of environmentally-friendly products. | |
| | INV5 | Suppliers were selected after the design for environmentally-friendly products was completed. ^ | |
| Collaborative planning with suppliers on environmental issues | COL1 | We collectively work with our suppliers on the achievement of environmental goals. | Vachon and Klassen (2006) |
| | COL2 | We work together with our suppliers to develop a mutual understanding of responsibilities regarding environmental performance. | |
| | COL3 | Our company and suppliers work together to reduce the environmental impact of our activities. | |
| | COL4 | We conduct joint planning activities with our suppliers to anticipate and resolve environmental-related problems. | |
| | COL5 | We make joint decisions with our suppliers about ways to reduce overall environmental impact of our products | |

^ Reverse coded items.

**Table 3.1.** Green supply management practices

| **Green Supply** | **Sources** |
|---|---|
| **Monitoring** | |
| Provide suppliers with detailed, written environmental requirements | Klassen (2001), Montabon et al. (2007), Zhu and Sarkis (2004) |
| Evaluation of Suppliers' environmental performance | Bowen et al. (2001), Klassen and Vachon (2003), Kocabasoglu et al (2007), Lee and Klassen (2008), Montabon et al. (2007), Zhu and Sarkis (2004) |
| Selection of supplier based on environmental criteria | Bowen et al. (2001), Klassen and Vachon (2003), Lee and Klassen (2008), Montabon et al. (2007) |
| Certification of suppliers, inputs, products, and activities | Jacobs et al. (2010), Klassen and Vachon (2003), Zhu and Sarkis (2004) |
| Environmental audit for suppliers' internal management | Montabon et al. (2007), Zhu and Sarkis (2004) |
| Supplier incentive program | Klassen and Vachon (2003), Kocabasoglu et al (2007), Montabon et al. (2007) |
| Provide suppliers with feedback about the results of their evaluations. | Klassen and Vachon (2003) |
| **Supplier involvement** | |
| Early supplier involvement | Montabon et al. (2007) |
| Eco-design | Zhu and Sarkis (2004) |
| **Collaborative planning** | |
| Joint efforts (such as planning, goal setting, performance measurement) to solve environmental-related problem | Bowen et al. (2001), Lee and Klassen (2008), Zhu and Sarkis (2004) |
| Offer technical assistance to our suppliers. | Klassen and Vachon (2003) |
| Provide training, education and site visits to supplier | Jacobs et al. (2010), Klassen and Vachon (2003), Kocabasoglu et al (2007), Lee and Klassen (2008) |
| Communication | Klassen and Vachon (2003), Montabon et al. (2007) |

**Table 3.2: Demographic data (230 respondents)**

| | N | Percentage |
|---|---|---|
| *Industry* | | |
| NAICS 31-33 (Manufacturing) | 187 | 81.3% |
| NAICS 51 (Information) | 13 | 5.7% |
| Other NAICS | 30 | 13.0% |
| | | |
| *Respondents* | | |
| **Gender** | | |
| Male | 191 | 83.0% |
| Female | 39 | 17.0% |
| **Age** | | |
| 20-30 | 7 | 3.0% |
| 31-40 | 30 | 13.0% |
| 41-50 | 84 | 36.5% |
| 51-60 | 85 | 37.0% |
| 61 or more | 24 | 10.5% |
| **Job Title** | | |
| CEO, President | 6 | 2.6% |
| VP, Director | 48 | 20.9% |
| Manager, Department Head | 121 | 52.6% |
| Supervisor, Leader, Senior, Assistant Manager | 14 | 6.1% |
| Agent, Buyer, Planner, Engineer | 34 | 14.8% |
| Other | 7 | 3.0% |
| **Work Experience** (years) | | |
| <5 | 5 | 2.2% |
| 5-10 | 6 | 2.6% |
| 11-20 | 57 | 24.8% |
| 21-30 | 85 | 37.0% |
| 31-40 | 68 | 29.5% |
| >41 | 9 | 3.9% |

**Table 3.3**: Descriptive statistics and correlations matrix

| | Mean | Std. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|---|
| 1.Stakeholder Pressure | 2.83 | 0.81 | 1 | | | | | | |
| 2. Competitive Pressure (Rival Pressure) | 4.07 | 1.15 | 0.321** | 1 | | | | | |
| 3.Top Management Support | 5.03 | 1.33 | 0.385** | 0.362** | 1 | | | | |
| 4.Environmental Monitoring on Suppliers | 3.39 | 1.44 | 0.337** | 0.445** | 0.423** | 1 | | | |
| 5. Supplier involvement on Green Product Development | 4.15 | 1.25 | 0.384** | 0.411** | 0.390** | 0.593** | 1 | | |
| 6. Environmental Collaborative Planning with Suppliers | 3.45 | 1.57 | 0.329** | 0.403** | 0.395** | 0.626** | 0.618** | 1 | |
| 7. Firm Size (Log Sales) | 2.90 | 0.945 | 0.236** | 0.311** | 0.251** | 0.270** | 0.182** | 0.298** | 1 |

*** significant at the 0.01 level*

**Table 3.4:** Convergent validity and reliability

| **Construct** | **Label** | Standardized Loading | Cronbach's Alpha | Composite Reliability |
|---|---|---|---|---|
| Stakeholder Pressure on environmental management | STA1 | 0.714 | .841 | .783 |
| | STA2 | 0.818 | | |
| | STA 3 | 0.719 | | |
| | STA4 | 0.756 | | |
| | STA5 | 0.738 | | |
| Competitive Pressure on environmental management | COM1 | 0.797 | .899 | .950 |
| | COM2 | 0.862 | | |
| | COM3 | 0.890 | | |
| Top management support for environmental initiatives | TOP1 | 0.840 | .921 | .918 |
| | TOP2 | 0.966 | | |
| | TOP3 | 0.907 | | |
| Monitoring on suppliers' environmental performance | MON1 | 0.906 | .925 | .941 |
| | MON2 | 0.885 | | |
| | MON3 | 0.901 | | |
| | MON4 | 0.849 | | |
| | MON5 | 0.832 | | |
| | MON6 | 0.901 | | |
| involvement of suppliers in environmental-friendly product development | INV1 | 0.887 | .927 | .948 |
| | INV2 | 0.947 | | |
| | INV3 | 0.964 | | |
| | INV4 | 0.969 | | |
| | INV5 | 0.733 | | |
| Collaborative planning with suppliers on environmental issues | COL1 | 0.963 | .970 | .980 |
| | COL2 | 0.970 | | |
| | COL3 | 0.971 | | |
| | COL4 | 0.937 | | |
| | COL5 | 0.939 | | |

**Table 3.5:** Discriminant validity test

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1.Stakeholder Pressure | **0.562** | 0.103 | 0.148 | 0.114 | 0.147 | 0.108 |
| 2. Competitive Pressure (Rival Pressure) | 0.321** | **0.723** | 0.131 | 0.198 | 0.169 | 0.162 |
| 3.Top Management Support | 0.385** | 0.362** | **0.820** | 0.179 | 0.152 | 0.156 |
| 4.Environmental Monitoring on Suppliers | 0.337** | 0.445** | 0.423** | **0.773** | 0.352 | 0.392 |
| 5. Supplier involvement on Green Product Development | 0.384** | 0.411** | 0.390** | 0.593** | **0.818** | 0.382 |
| 6. Environmental Collaborative Planning with Suppliers | 0.329** | 0.403** | 0.395** | 0.626** | 0.618** | **0.914** |

*Note: Diagonal entries (in bold) are average variances extracted, entries below the diagonal are correlations, and the entries above the diagonal represent the squared correlations.*
*** significant at the 0.01 level*

**Table 3.6:** Mediation test (Baron and Kenny (1986) test)

| Paths | M1 | M2 |
|---|---|---|
| STA to MON | 0.158* | 0.119 |
| STA to INV | 0.171* | 0.142 |
| STA to COL | 0.149* | 0.115 |
| COM to MON | 0.186** | 0.144 |
| COM to INV | 0.177* | 0.145 |
| COM to COL | 0.172* | 0.135 |
| STA to TOP | - | 0.242** |
| COM to TOP | - | 0,265*** |
| TOP to MON | - | 0.169* |
| TOP to INV | - | 0.168* |
| TOP to COL | - | 0.147* |

***significant at 0.001 level; **significant at the 0.01 level * significant at the 0.05 level

**Table 3.7:** Indirect effects analysis

| Constructs | MON | INV | COL |
|---|---|---|---|
| STA | | | |
| Indirect Effect | 0.062*<br>(0.009, 0.116) | 0.059*<br>(0.002, 0.106) | 0.054*<br>(0.007, 0.105) |
| | | | |
| COM | | | |
| Indirect Effect | 0.068*<br>(0.015, 0.121) | 0.054*<br>(0.009, 0.109) | 0.061*<br>(0.010, 0.112) |

*significant at 0.05 level
The numbers in the parentheses are 95% confidence interval based n=5000 bootstrap.

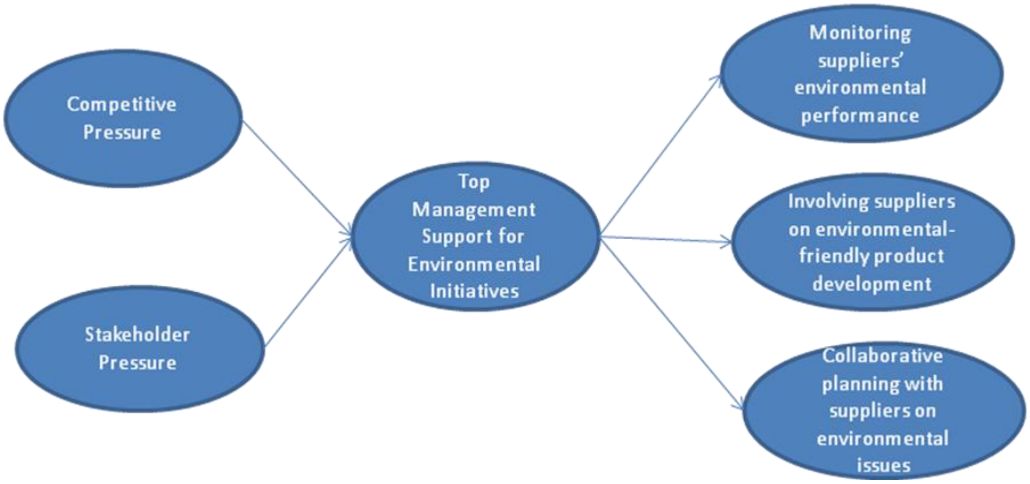


***Figure 3.1*** *Theoretical Model*

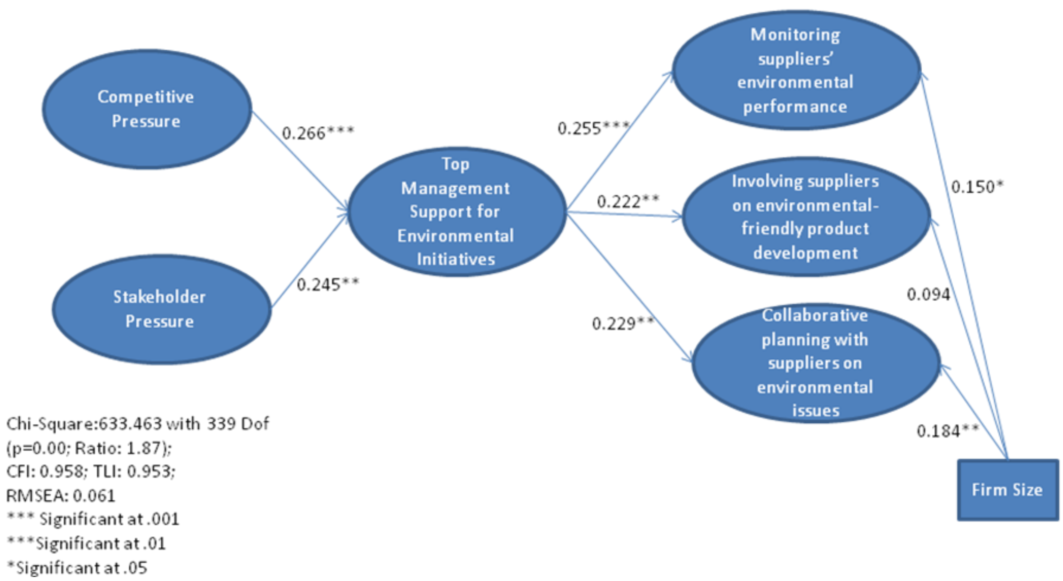


***Figure 3.2*** *Model Results*

# CHAPTER 4

# EXPLORING HOW ENVIRONMENTAL MANAGEMENT COMPETITIVE PRESSURE AFFECTS A FOCAL FIRM'S ENVIRONMENTAL INNOVATION ACTIVITIES: A GREEN SUPPLY CHAIN PERSPECTIVE

## 4.1 Introduction

The development of new environmental management innovations into the marketplace is critical to the success **o**f today's firms (Tate et al., 2010). Environmental management practices provide firms with a source of competitive advantage in the marketplace (Hofer, Cantor, and Dai, 2012; Bansal and Roth, 2000). Apple Corporation and its competitor Dell provide an illustrative example of how companies are engaging in environmental management competitive moves and counter-moves. Only after discovering that Dell Corporation had proactively disclosed its environmental ratings, Apple Corporation reacted to Dell's competitive move by revealing the amount of carbon emissions associated with the manufacture and use of its products (Engardio et al., 2007). Moreover, Apple countered Dell's environmental actions by introducing green products by using environmentally-friendly materials in its devices, which put Apple well ahead of its rival Dell (Burrows, 2009).

Drawing on the Schumpeterian perspective of competition, our study examines how environmental management competitive pressure from main competitors influences a firm to pursue and produce new environmental innovations into the marketplace (e.g., focal firm's green success). The Schumpeterian perspective of competition suggests when a firm observes that its rivals reap benefits from competitive activities, it will react by weakening its rivals' competitive advantage and develop its own new product innovations (Grimm and Smith, 1997). To counteract such competitive moves, firms are increasingly using their internal resources and supply chain integration activities to introduce new environmental innovations into the marketplace (Kiron et al., 2013).

This study examines how environmental management competitive pressure from main competitors influences a focal firm's environmental innovation activities through its green supply chain integration activities. Supply chain integration activities enable a firm to engage in competitive moves and counter-moves. Thus supply chain integration is a pivotal determinant of new product and innovation development success (e.g. Swink, 2006; Teece, 2009; Song and Benedetto, 2008). Supply chain integration (SCI) consists of a focal firm's collaboration with internal cross-functional teams, external customers, and suppliers. In this study, we use the term green supply chain integration (GSCI) to describe three forms of collaboration -- internal integration of green product development, customer integration of green product development, and supplier integration of green product development. Compared to traditional product development processes, the environmental innovation development process is more complex and requires a firm to utilize GSCI capabilities. All stages of the environmental design, manufacturing, and distribution process must be considered by the firm in addition to traditional new product objectives and issues (Peattie 1992; Thomas, 1993).

To react to environmental management competitive pressure from main competitors, coordination and integration of internal organizational functions and external supply chain partners is required (Lee and Klassen 2008). Previous studies have shown that a firm achieves internal integration first and then external integration in order to increase information sharing (Carr and Kaynak, 2007) and improve new product development success (Koufteros et al., 2005). In a recent study, Braunscheidel and Suresh (2009) and Zhao et al., (2011) found that internal integration has a positive influence on external integration which includes supplier and customer integration as two subdimensions. It is noted that manufacturers need to coordinate between internal and external green supply chain management practices to realize their performance potential to the fullest (Zhu et al., 2012). However, we have limited knowledge about how to effectively coordinate green supply chain integration to achieve improved competiveness. Therefore, there is a need for empirically test the relationship between internal integration and external supplier and customer integration to improve our understanding of the mechanisms of green supply chain integration to compete with rivals and develop environmental innovation.

This study makes several contributions to the green supply chain management literature and practice. First, we draw on the Schumpeterian perspective of competition to build our research model. We propose that environmental management competitive pressure from main competitors drives a focal firm to introduce environmental innovations to the marketplace. The coordinating mechanism between internal integration and external integration of green product development is also examined. Second, we test our hypothesized model by using a sample of supply chain managers in US public traded companies. The empirical results provide the evidence that environmental management competitive pressure from main competitors is an important determinant for a firm to adopt green supply chain integration activities. Empirical evidence also provides insights to practicing managers on how to devote their efforts and resources in different dimensions of green supply chain integration, and how to manage green supply chain integration to achieve environmental innovation. Third, by differentiating incremental environmental innovation and radical environmental innovation, this study will reveal the role of three dimension of green supply chain integration on incremental and radical environmental innovation separately. Empirical evidence will also demonstrate the relative importance of internal integration and external supplier and customer integrations in developing incremental and radical environmental innovation. Lastly, we also examine the green product development process in supply chains by identifying there subdimesions of green supply chain integration. Our study is among the first studies to examine supply chain integration in the domain of green product development and environmental innovation.

The remainder of the paper is organized as follows: First, the theoretical background and research hypotheses are described. Next, the research methodology is presented, followed by the presentation of the analyses and results. Subsequently, managerial implications are discussed. Finally, main conclusions are drawn, together with suggestions for future research.

## 4.2 Theoretical Framework and Research Model

The Schumpeterian view of competition and supply chain integration literature serve as the theoretical frameworks of this study. The Schumpeterian view has been previously adopted to explain how and why firms engage in competitive moves and counter moves (Young et al., 1996). The Schumpeterian view of competition is based on the contention that competitive actions trigger competitive responses by rivals (Schumpeter, 1934, 1942). Based on the Schumpeterian view of competition, researchers have examined the extent to which firms implement environmental management activities in response to their rivals' environmental management efforts (Hofer et al., 2012).

In order to obtain their own competitive advantage from environmental practices in lieu of a rival's environmental management success, many firms develop and introduce environmental innovations to the market. The benefits, such as resource productivity derived from environmental innovations may offset the cost of implementing environmental management and enable firms to act more competitively (Porter and Van der Linde, 1995a,b; Kiron et al., 2013). Anecdotal evidence exists that firms are collaborating and integrating with their supply chain partners, customers or suppliers, to develop environmental innovation. For example, Timberland, for example, worked closely with its supply chain for leather, a key material in many of its products, to improve efficiencies and reduce costs. UPS is turning to its suppliers to help reduce emissions and costs from its transportation fleet. Dell relies on its supply chain to solve product packaging issues: the firm's clients desire reliable packaging to ensure equipment will arrive undamaged, while Dell wants lighter packaging material to reduce its shipping costs. Dell found a Chinese company that was experimenting with bamboo fibers as a substitute for paper used in cardboard packaging.

A focal firm will need to enhance in green supply chain integration capabilities to respond to a rival's product innovation activities. Green supply chain coordination and integration is required (Lee and Klassen 2008). In this study, green supply chain integration consists of the integration of internal functions, as well as the integration with customers and suppliers for green product development (Mishra and Shah, 2009). The supply chain integration literature suggests that to implement external integration with customers and suppliers, firms need to pursue internal integration activities first because it acts as foundation to provide necessary experience of knowledge sharing and working together. Thus, we argue that competitive pressure from rivals drives the adoption of internal integration and then external customers and suppliers integration, and finally enables the development of incremental and radical environmental innovation (see Figure 4.1).

### 4.2.1 Effect of environmental management competitive pressure from main competitors on internal integration of green product development

It is critically important for a focal firm to continuously observe its competitors' activities and strategies (Narver and Slater, 1990). According to the Schumpeterian view of competition, firms can attain competitive advantage over time by taking action (Jacobson, 1992). When finding out that a main competitor derives benefits from the implementation of environmental management activities, a focal firm will often counteract in order to respond to a rivals' competitive advantage and build its own competitiveness. For example, Coke developed technology to produce fully recyclable plastic bottles that are 30% composed of plastic made from sugar cane. Coke won the praise of a "green star" rating through this sustainability project (Dubios, 2011).

PepsiCo, Coke's main competitor, declared that it plans to develop competing technologies and to conduct a test next year that involved producing 200,000 bottles made from plant-only plastic (Neuman, 2011).

Developing environmental innovations is an effective way to respond to a main competitors' green success. Firms will coordinate with different key stakeholders within the boundaries of the organization as a way to facilitate the sharing of real-time information across key functional areas. Such coordination may require cross-functional coordination and collaboration across different functional areas (Follett, 1993), where integration across product design, procurement, production, sales and distribution functions takes place to meet green requirements and to compete with rivals at a low total system cost (Morash et al., 1997). Thus we argue:

***H1:*** Environmental management competitive pressure from main competitors is positively associated with a firm's internal integration of green product development.

**4.2.2 Effects of internal integration on external integration of green product development**

Excellent internal integration capabilities will lead to strong external integration capabilities. High levels of internal communication and coordination capabilities will enable the firm to achieve high levels of external integration. In particular, when a company has a high level of absorptive capability (Cohen and Levinthal, 1990) to disseminate, interpret, utilize, and evaluate new knowledge acquired from external suppliers and customers, the company will more likely learn from external partners and understand their business to facilitate external integration. As a result, internal integration represents an absorptive capability for learning from external partners (e.g.

Hillebrand and Biemans, 2004; Lane et al., 2006), as well as an internal coordination capability for external coordination (Takeishi, 2001).

Green product development usually involves information sharing and working together. Internal integration efforts break down functional barriers and facilitate the sharing of real-time information across key functions (Wong et al., 2007). Companies that already enjoy well-established internal systems and capabilities for integrating data and sharing information among their internal functional units can more readily add functional modules to link with external customers and suppliers and identify critical issues regarding suppliers and customers (Bhatt, 2000; Crocitto and Youssef, 2003). For most companies, interactions with suppliers are mainly conducted by the purchasing function, while interactions with customers are usually conducted by the marketing function. Internal information sharing or coordination is helpful for understanding and closely cooperating with suppliers and customers. If there is no effective information sharing or coordination between internal functions, the company will be hard pushed to fully understand supplier or customer requirements. Recent empirical research also provide evidence to support that internal collaboration between departments is related to external cooperation with partners (e.g., Stank et al., 2001; Carr and Kaynak, 2007). For example, Koufteros et al. (2005) found that concurrent engineering, which is “the early involvement of a cross-functional team in a process to plan product design, process design, and manufacturing activities simultaneously” (p. 100) directly enhanced customer integration and supplier integration, in product development activities. Biemans (1991) also stated that, in order to be effective in external cooperation, organizations need well-functioning internal interfaces. Therefore, we argue that a company performing well in internal integration will more likely integrate with external partners (Kanter, 1994).

***H2a:*** A firm's internal integration of green product development is positively associated with a firm's customer integration of green product development.

***H2b:*** A firm's internal integration of green product development is positively associated with a firm's supplier integration of green product development.

**4.2.3. Effects of green supply chain integration on environmental innovation**

Environmental innovation is defined as a specific kind of technical innovation that consists of new products and processes to avoid or reduce environmental burden (Ziegler and Nogareda, 2009). Arundel et al. (2007) notes that a better understanding of the factors that can encourage the development of radical and/or incremental environmental innovations are needed. In order to further our understanding of the role of suppliers in the development of environmental innovation, we examine environmental innovation from both an incremental and radical environmental innovation perspective. In our study, incremental environmental innovation refers to minor improvements or simple adjustments in existing environmental technologies including green products and environmental management processes (Arundel et al., 2007; Li et al., 2008). Radical environmental innovation refers to fundamental changes that represent revolution in environmental technology including green products and environmental management processes (Arundel et al., 2007; Li et al., 2008; Slocum and Rubin, 2008).

Green supply chain integration is a significant way to facilitate both incremental and radical environmental innovation. The innovation process requires the creation and application of new knowledge (Schoonhoven, Eisenhardt, and Lyman, 1990). Greater innovation requires greater knowledge development (Dewar and Dutton, 1986), beyond the current knowledge base and zone of comfort of the organizational entity (Itami and Namagami, 1992; Cohen and Levinthal, 1990). Major innovations require new skills, levels of market understanding, and better information processing abilities and systems throughout the organization (Moorman and Miner, 1997). Knowledge sharing is a basis of supply chain integration (Flynn et al., 2010; Zhao et al., 2011). Supply chain integration of green product development provides a platform of knowledge sharing within the organization and also among the supply chain partners, and thus provides the capability for both incremental and radical environmental innovation development.

Internal integration enables product design, engineering, manufacturing, and marketing departments to work closely in supporting concurrent engineering and design for manufacturing (Crawford, 1992). As suggested by the new product development and innovation literature, internal integration helps create a common-value-based focus instead of a function-oriented focus (Eisenhardt and Tabrizi, 1995). A common-value-based focus increases both incremental and radical innovation development by (1) enabling knowledge sharing across functions and manufacturing plants (Roth, 1996; Narasimhan and Kim, 2002; Cao and Zhang, 2011), (2) advancing mutual support, cooperation, and coordination (Hoegl et al., 2004), and (3) reducing misunderstandings among team members (Atuahene-Gima, 2003). Specifically, involving manufacturing during the entire green product development process can provide essential input concerning what is or is not feasible, as well as develop the expertise needed to move beyond current capabilities (Calantone et al., 2003; Swink and Song, 2007). Thus, we propose:

***H3a:*** A firm's internal integration of green production development is positively associated with a firm's incremental environmental innovation.

***H3b:*** A firm's internal integration of green production development is positively associated with a firm's radical environmental innovation.

Firms also increasingly rely on external knowledge to engage in innovation activities. Important sources of external knowledge are a firm's suppliers and customers who have a wealth of information and experience with different technologies (Swink, 2006; Teece, 2009). Ahuja (2000) notes that collaboration with suppliers and customers would not only provide the benefit of resource sharing (i.e., allowing firms to combine knowledge, skills and physical assets), but also provide access to knowledge spillovers.

Listening to the voice of the customer is a critical source of success for many firms. Involving the customer in the act of innovation is essential for organizational survival because customers provide insights, ideas, thoughts, and information about how the firm can improve existing products and services (Desouza et al., 2008). Customer integration involves determining customer requirements and tailoring internal activities to meet these requirements. As a firm gets to know its customers better and becomes committed to understanding and meeting their needs, a strong linkage is forged between the company and its customers. A close customer relationship helps a firm to recognize new ideas and opportunities and to prevent a mismatch between ideas and needs (Ittner and Larcker, 1997). In the environmental innovation development, customer integration ensures that the voice of the customer plays a vital role in the innovation process within the organization. For instance, Greif worked with customers to analyze the life cycle of several of its products. The collaboration identified new business opportunities connected with reconditioning and extending the life of a major product line, steel and plastic drums (Kiron et al., 2013). Thus, we propose:

***H4a:*** A firm's customer integration of green production development is positively associated with a firm's incremental environmental innovation.

***H4b:*** A firm's customer integration of green production development is positively associated with a firm's radical environmental innovation.

A focal firm's integration with its supplier based serves as our next important factor that affects environmental innovation (Koufteros et al., 2005). A partnership of this nature is characterized by early supplier involvement, joint efforts, and communication. Integrating suppliers into environmental activities helps a firm to identify potential technical problems such as contradictory specifications or unrealistic designs, early in the design-for-environment process and thus speeds up both incremental and radical environmental innovation development and responses to market demands (Kessler and Chakrabarti, 1996). Integrating suppliers into the environmental innovation development process also facilitates outsourcing and external acquisition possibilities thereby reducing the internal complexity of environmental innovation projects and shortening the critical path for environmental innovation development.

Joint efforts and communication within the buyer-supplier collaboration effort helps the supplier to better understand the buying firm's plans and expectations in environmental management and decrease inter-firm conflict. Moreover, through open and honest communication and joint efforts, firms can create a supportive and trusting environment to facilitate and increase the supplier's commitment to their relationship (Henke and Zhang, 2010). The supplier's commitment, demonstrated by a supplier's willingness to invest in environmental technology and to share environmental technology with a buying firm, is an important component of both incremental and radical environmental innovation in the networked environment (Gundlach et al., 1995). Researchers have examined the effect of supplier integration on environmental innovation and argued that knowledge from suppliers is essential and an important component of environmental innovation (e.g., Geffen and Rothenberg, 2000; Rao, 2002). For example, UPS is turning to technology suppliers to help reduce emissions and costs from its transportation fleet. Amazon has worked with suppliers such as Philips to cut out the clamshells and stick with boxes that are made from recyclable materials. Thus, we propose:

***H5a:*** A firm's supplier integration of green production development is positively associated with a firm's incremental environmental innovation.

***H5b:*** A firm's supplier integration of green production development is positively associated with a firm's radical environmental innovation.

## 4. 3Methodology

### 4.3.1 Survey development and sample

To study our hypothesized relationships, following the procedures and guidelines recommended by Churchill (1979), Gerbing and Anderson (1988), and Dillman (2000), a web-based survey instrument was developed. We conducted an extensive review of the literature to assist with identifying the constructs in the model. In so doing, established measures were adopted directly or modified slightly to operationalize each of the constructs. This process involved making word and sentence changes so that all items fit our research context. A preliminary questionnaire was then reviewed by seventeen industry practitioners (mid- or senior-level supply chain managers) and MBA students. These practitioners provided feedback on any issues of ambiguity, readability, and clarity. Two SCM professors and four PhD students also reviewed the survey for item specificity, face validity and content validity. The questionnaire was revised based on feedback from these practitioners and academics.

To ensure data confidentiality, the web-based survey was administered by a large public US university. Following the recommendations of Dillman (2000) and because of the potential for a low survey response rate, we notified in advance 3,490 potential supply chain professional respondents by phone about our survey. In so doing, we hired and trained undergraduate and graduate students to telephone the potential survey respondents. The list of potential survey respondents was derived from a Dun and Bradstreet (D&B) database. As described by Dillman (2000), pre-notifying potential survey respondents helps to improve survey response rates. Moreover, survey respondents were motivated to participate in this study because the subject matter of our questionnaire is viewed as a current topic that could impact the key informant's profession. After calling the potential survey respondents, our student research assistants emailed the D&B contacts with a link to the online questionnaire. The student research assistants also provided a brief explanation of our research project including the study's objectives. As suggested by Dillman (2000), our student research assistants also made follow-up telephone calls and sent reminder emails to the survey non-respondents. Additionally, to encourage participation in the research project, we offered a summary of the results to the survey respondents (Dillman, 2000).

The population for the survey are supply chain management professionals who are both employed by publicly traded firms in the United States and listed in the Dun and Bradstreet database. Based on our pre-notification and follow-up procedures, we were able to determine that 197 respondents formally declined to participate in the survey because of company policy, other time commitments, or lack of interest in the survey topic. We also discovered that 1,425 respondents are no longer employed by their organization. Our student research assistants were unable to contact 419 supply chain professionals by telephone or voicemail because the D&B database contained inaccurate email addresses or the phone numbers provided are no longer in service. A total of 1,449 potential respondents received an emailed link to the web-based survey. We received 264 responses. After excluding 34 incomplete survey responses, 230 useable observations were retained out of 1,449 contacts, resulting in a response rate of approximately 16% (230/1,449). The executives who responded to the survey had titles such as Director of Supply Chain Management, Director of Purchasing, Vice President of Logistics, and Chief Purchasing Officer.

Demographic data is shown in Table 4.1. Over eighty percent (81.3%) of the respondents are from manufacturing industries. About ninety-five percent of the survey respondents have more than ten years of work experience. On average, the key informant worked for a company where total sales are approximately $5.9 billion.

### 4.3.2 Non-response bias

In this study, we evaluated survey non-response bias using two approaches. First, the responses of early and late responses were compared (Lambert and Harrington, 1990; Armstrong and Overton, 1977). T-tests were performed on the responses of these two groups which yielded no statistically significant differences at the 99% level across several demographic variables, including job position, work experience, industry type, respondent age and gender. As a second test of non-response bias, we randomly selected 300 companies from the list of firms that did not participate in our study. We collected firm size information to assess non-response bias (i.e., number of employees as well as annual firm sales). The firm size information was combined with the firms that did participate in our study. The sample and the population means of the firm size variables were compared. Our t-tests yielded no statistically significant differences at the 99% confidence interval between the sample and population. These results suggest that non-response does not appear to be a serious problem.

### 4.3.3 Constructs in the model

The variables used in this study are based on well-established items in the operations management literature. A complete list of the items used is provided in Appendix 4.A. We now turn to describing the control variables used in our model. We controlled for the size of the firm. Larger firms tend to have access to more resources than smaller firms to implement environmental management activities with suppliers. We expect that larger firms would be more likely to implement green supply practices. Firm size is measured by total sales. The firm size data is derived from the Compustat database. Because this variable is skewed, we log transformed this variable. We also controlled for the firm's research and development (R&D) expenditures which is also derived from the Compustat database. Firms engaged in innovative activities dedicate more resources to R&D. Because firms make R&D investments across multiple time periods, we created a recent five-year time-weighted R&D stock variable where the most recent year is weighted the most.

## 4.4 Analysis and Results

We now examine the reliability and validity of our constructs. In particular, we adopted Gerbing and Anderson's (1988) two-step approach, which consists of first examining the measurement model and then the structural model to analyze the data. We assessed the measurement model including convergent validity and discriminant validity in order to assure that the measures used in the analysis are reliable and valid. Table 4.2 presents descriptive information on each variable and the correlations across constructs.

**4.4.1 Measurement instrument validation**

Construct validity is the extent to which the items on a scale measure the abstract or theoretical construct of interest (Churchill, 1979). Testing of construct validity concentrates not only on finding out whether an item loads significantly on the factor (i.e., convergent validity) but also on ensuring that it measures no other factors (i.e., discriminant validity) (Campbell and Fiske, 1959). Convergent validity exists if a group of indicators are measuring one common factor. Convergent validity is demonstrated by the statistical significance of the loadings at a given alpha (e.g., p = 0.05). A loading of 0.7 indicates that about one-half of the item's variance (the squared loading) can be attributed to the construct. Thus, 0.7 is the suggested minimum level for item loadings on established scales (Fornell and Larcker, 1981). Composite reliability and average variance extracted were calculated using the procedures suggested by Fornell and Larcker (1981). Composite reliability (CR) for each construct is above 0.90, and average variance extracted (AVE) is above 0.70. Cronbach alpha values of all factors are well above 0.80. Thus convergent validity is sufficiently achieved.

Discriminant validity among the constructs was assessed by first evaluating whether the intercorrelation among the constructs is less than .70 which suggests the constructs have less than half their variance in common (Hair et al., 2010). All pairs of constructs meet this threshold. Also discriminant validity was assessed by comparing the average variance extracted (AVE) for each construct with the square of the correlation between all possible pairs of constructs (Hair et al., 2010). In all cases, the AVE is greater than the square of the correlation between all possible pairs of constructs (Table 4.4). Overall, the results offer support for discriminant validity among the constructs.

**4.4.2 Common method bias**

Our study employed multiple methods to mitigate potential effects of common method bias. First, we surveyed the supply chain professions of each firm who are knowledgeable about their operations. They are recognized to be reliable sources of information and hence minimize the potential of common method bias (Miller and Roth, 1994; Narayanan et al., 2011). Second, we performed Harman's single factor test for survey data using a confirmatory approach in order to assess the degree of common method bias in the data ($\chi 2$=5163.736, Dof=324, p=0.00, CFI=0.535, TLI=0.497 and RMSEA=0.254). Our Harmon's single factor test results are considerably worse than those of the measurement model ($\chi 2$=593.996, Dof=298, p=0.00, CFI=0.972, TLI=0.967 and RMSEA=0.066). This suggests that a single factor is not acceptable, thus further suggesting that common method bias is not a concern. Third, to further assess common method bias, we tested a measurement model having only the traits (trait-only model) first and then added a single method factor to the trait-only model (Widaman, 1985; Podsakoff, et al., 2003; Cao and Zhang, 2011; Zacharia et al., 2011). The results of this test indicate that the added method factor only accounts for 3.2% of the total variance, which is below the 10% threshold suggested by Paulraj, Lado, and Chen (2008). Also, the item loadings for their factors are still significant even when the method factor is included in the model. Finally, following the approach recommended by Lindell and Whitney (2001), we checked for the impact of method variance by using the lowest bi-variate correlation among the manifest variables as the marker variable. We computed the adjusted correlation matrix and tested the significance of the adjusted correlations. All correlations remain significant after the adjustment. Lindell and Whitney (2001, p. 118) state that “if any zero-order correlations that were statistically significant remain significant, this suggests that the results cannot be accounted for by CMV.” Based on the above findings, it is reasonable to conclude that common method bias is not a serious concern.

**4.4.3 Hypothesis testing**

Next, we tested our hypotheses using structural equation modeling. The fit indices of our model meet the cut-off values suggested by Hu and Bentler (1999) ($\chi2$= 667.008, Dof=311, p=0.00, $\chi2$/Dof=2.14, CFI=0.966, TLI=0.962, and RMSEA=0.070).

All hypotheses are supported. As expected, environmental management competitive pressure from main competitors is positively related ($\beta$=0.289, $p<.001$) to a firm’s internal integration of green product development (H1). A firm’s internal integration of green product development is positively associated with both customer integration of green product development ($\beta$=0.840, $p<.001$) and supplier integration of green product development ($\beta$=0.814, $p<.001$), thus H2a, and H2b are supported. On incremental environmental innovation, a firm’s internal integration ($\beta$=0.308, $p<.01$), customer integration ($\beta$=0.199, $p<.05$) and supplier integration ($\beta$=0.253, $p<.01$) of green product development all have significant impact in a positive way. Thus H3a, H4a and H5a are all supported. On radical environmental innovation, a firm’s internal integration ($\beta$=0.328, $p<.05$), customer integration ($\beta$=0.309, $p<.01$) and supplier integration (β=0.218, p<.05) of green product development all have significant impact in a positive way, thus, H3b, H4b and H5b are all supported. Both control variables have no significant effect on environmental innovation. Figure 4.2 presents the model results.

**4.4.4 Mediation analysis**

We now examine the mediating effects of internal integration of green product development on the relationship between environmental management competitive pressure from main competitors on customer integration of green product development, and on the relationship between environmental management competitive pressure from main competitors and supplier integration of green product development. To assess the mediation effect we conducted additional statistical test by following Baron and Kenny (1986) which has been used in the environmental management literature (Sarkis et al. 2010). To evaluate mediation, we propose two SEM models. The first model (M1) focuses on the direct relationship between the endogenous variables (customer and supplier integration of green product development) and exogenous variable (environmental management competitive pressure from main competitors), while the second model (M2) incorporates the mediating factor of internal integration of green product development. As stated by the results listed in Table 4.5, in M1, the exogenous variable (main competitors' green success) has a positive and statistically significant influence on the endogenous variables (customer integration and supplier integration). In M2, the exogenous variable (environmental management competitive pressure from main competitors) significantly impacts the mediator (internal integration of green product development), and the mediator also significantly affects the endogenous variables (customer and supplier integration of green product development) in a positive way. Additionally, the effect of the main competitors' green success on the supplier integration of green product development is diminished after controlling for the effects of the mediator. Based on Baron and Kenny (1986), this situation suggests that internal integration of green product development fully mediates the relationships between environmental management competitive pressure from main competitors and the supplier integration of green product development. However, the effect of environmental management competitive pressure from main competitors on the customer integration of green product development is not diminished but reduced in the significance level after controlling for the effect of the mediator, which suggests internal integration of green product development partially mediates the relationships between environmental management competitive pressure from main competitors and the customer integration of green product development.

**4.4.5 Competing model analysis**

One purpose of this paper is to empirically examine how a focal firm responds to environmental management competitive pressure from main competitors by implementing green supply chain integration and then develop environmental innovation. In our model, we propose that a focal firm would internally integrate first and then externally (supplier and customer) integrate. In order to demonstrate that our model fits the data best, we present alternative models as a way to conduct competing model analysis (Bollen and Long, 1992; Cudeck and Browne, 1983). We thus compared our hypothesized model (Model 1) to two rival models to further validate that our hypothesized model is a strong model. Model 2 assumes environmental management competitive pressure from main competitors leads to external (customer and supplier) integration of green product development first and then external (customer and supplier) integration of green product development leads to internal integration of green product development; Model 3 assumes environmental management competitive pressure from main competitors drives a focal firm to engage in three dimensions of green supply chain integration simultaneously (internal, customer, supplier integration of green product development) but there is no causal relationship among green supply chain integration. We present our competing model analysis results in the Table 4.6. Although we find significant positive relationship as suggested in M2 and M3, the model fit index of M2 and M3 are worse than those of M1. The larger CFI and TLI values and the smaller $\chi2$/Df, RMSEA, and AIC values are preferred as indicators of stronger model fit. Thus, the results provide support that our hypothesized model is a stronger model compared to the alternative models.

## 4.5 Discussion

### 4.5.1 Environmental management competitive pressure from main competitors on green supply chain integration

The purpose of this study is to examine how environmental management competitive pressure from main competitors influences a firm to pursue and produce new environmental innovations into the marketplace (e.g., focal firm's green success). Recent research on the drivers of environmental practices adoption and green supply chain management (e.g. Hofer et al., 2012) suggests that rivals play an important role for a firm's adoption of environmental practices. Drawing-upon the Schumpeterian perspective of competition, our study examines how rivalry influences a firm to engage in environmental innovation activities. Firms are increasingly focusing on developing environmentally friendly products and strategies in order to react to pressure from rival firms. In order to maintain their competitive advantage, a focal firm reacts to those that they perceive as successful in this regard (Perrow, 1961). Pressures from competitors drive a firm's adoption of innovative ideas and new technology (Grimm and Smith, 1997; Zsidisin et al., 2005). When a firm observes that its rivals have derived benefits from the adoption of environmental practices, the focal firm will begin to implement environmental management practices such as supply chain integration of green product development. The focal firm will work with internal cross-functional teams, suppliers, and customers in order to create environmentally innovative products.

Firms need to enhance their supply chain integration of green product development activities in order to effectively compete the global marketplace. In today's competitive environment, companies are forced to cooperate closely with their suppliers and customers to meet various challenges, such as requirements of low cost, high quality, better delivery, flexibility, and environmental sustainability. Our findings indicate that in order for a focal firm to better respond to rival pressure to develop green products, the focal firm needs to move beyond strong internally-oriented green product development processes to externally-oriented green product development processes. For example, internal cross-functional teams are in a unique position to develop strong relationships with their external supply chain partners. The joint planning and information sharing of internal cross functional team can be assimilated and learned by internal functions in order to establish cooperative plans with external supply chain partners and improve green product development. Cross-functional teams play an important role in establishing trust and a cooperative environment with external supply chain partners. In so doing, cross-functional teams are important change agents who can build and maintain good relations with their supply chain partners. Our findings indicate that greatly improving a firm's internal processes can serve as an effective way in order to achieve effective integration with a focal firm's customers and suppliers. In fact, our study shows that internal integration of green product development is a mediator of the relationship between environmental management competitive pressure from main competitors and external integrations of green product development, suggesting that an effective approach to enhance external integration is to pursue internal integration.

Firms need to listen to the voice of the customer in its green product development activities. It has been recognized that customer pressure drives a firm's adoption of environmental practices (Sarkis et al., 2010; Dai and Blackhurst, 2012). Developing environmentally friendly products enables the firm to attract environmentally conscious customers. However, while firms are increasingly developing green products, some firms are unsure as to how receptive customers will be to these types of products (Tseng et al., 2012). Thus it is important for firms to incorporate customer feedback into the development of green products in the product development process. Our findings substantiate this perspective. In addition, we find that the relationship between environmental management competitive pressure from main competitors and customer integration of green product development is partially mediated by internal integration of green product development. This finding suggests that external customer integration of green product development can be enabled through internal integration, but it is also a direct reaction to environmental management competitive pressure from main competitors.

**4.5.2 Green supply chain integration (GSCI) on environmental innovation**

Innovation has long been recognized as an important firm performance measure. Environmental innovation is also critical to a firm's success because the benefits such as resource productivity derived from these innovations may offset the cost of implementing environmental management and enable the firm to act more competitively (Porter and van der Linde, 1995a, b). In this study, we extend existing environmental innovation research by exploring how green supply chain integration improves incremental and radical environmental innovation. The results of the green supply chain integratoin–innovation relationships (H3–H5) support our expectations and suggest that all three dimensions of green supply chain integration are important in the pursuit incremental and radical environmental innovation activities. Our findings are in alignment with the resource-based view of the firm (Barney, 1991) which emphasizes the importance of a firm's resources. Resources which are valuable, rare, and difficult to substitute or to imitate, are fundamental to the achievement of competitive advantage (Russo and Fouts, 1997) and therefore key for innovative activities (Teece, 2009). Internal integration and external customer and supplier integration of green product development are components of a firm's knowledge- and relational- based resource (e.g., Geffen and Rothenberg, 2000; Roy et al., 2004; Vachon and Klassen, 2008), which is more likely to be rare and difficult to copy than some tangible assets (e.g., financial resources).

Our theoretical model and empirical results provide further insights into the three dimensions of green supply chain integration and environmental innovation context. Our results offer evidence of the purported impacts of internal, supplier and customer integration of green product development on environmental innovation outcomes. Previous studies have demonstrated the positive impacts of internal integration on delivery and quality (Droge et al., 2004; Germain and Iyer, 2006; Swink et al., 2007) and production cost and production flexibility (Wong et al., 2011). Our results reinforce the argument for the need to remove functional barriers within and across organizational boundaries (Flynn et al., 2010) to create both incremental and radical environmental innovation.

Our results provide further evidence of how supplier and customer integration of green product development impact both incremental and radical environmental innovation. While previous studies have demonstrated the positive impact of external integration on operations management performance (Scannell et al., 2000; Rosenzweig et al., 2003; Droge et al., 2004; Devaraj et al., 2007) and product innovation (Koufteros et al., 2005), our results indicate that suppliers and customers are important sources of innovation who can help improve the focal firm's green product development activities through the facilitation of information exchange, task coordination, and cross-border problem-solving routines.

Our study further contributes to the literature by examining both incremental environmental innovation and radical environmental innovation. We also provide other very interesting findings that: 1) the impact of internal integration of green product development on radical environmental innovation is much stronger than those of supplier integration and internal integration of green product development; and 2) the impacts of supplier integration and internal integration of green product development on incremental environmental innovation are much stronger than that of customer integration of green product development. Usually, incremental innovation might involve less effort and resources (time, financial, or human resource) than radical innovation, and thus if the organization has limited capital and capability, they can choose to work internally or integrate with their suppliers to make minor improvements or simple adjustments in existing green products and environmental management process . On the other hand, our findings highlight the importance of building customer integration capacity in developing radical environmental innovation. For organizations with substantive capital and capability, developing radical environmental innovation would be a better choice for them. This is because radical environmental innovation represents fundamental change in environmental products and processes which provide greater environmental benefits to society and thus companies can enhance their image of a 'green leader' in the market. Additionally, these companies can charge premium prices when launching radical environmental innovation products and thus achieve greater profits. This is similar to the differentiation strategy suggested by Porter (1990). In order to obtain those competitive benefits from radical environmental innovation, firms can choose to involve their customers at early stage and develop green product collectively.

### 4.6. Conclusion

The purpose of this study is to examine how environmental management competitive pressure from main competitors drives a firm to implement green supply chain integration (GSCI) through which environmental innovation is developed. This paper advances green supply chain management research by developing and empirically testing the model based on a sample of US public traded companies. Our model shows how environmental management competitive pressure from main competitors influences three dimensions of green supply chain integration which can spawn incremental and radical environmental innovation. This study demonstrated environmental management competitive pressure from main competitors is an important reason for a firm to collaborate internally and externally with suppliers and customers to develop green products. . Internal integration of green product development fully mediates the relationship between environmental management competitive pressure from main competitors and supplier integration of green product development but partially mediates the relationship between environmental management competitive pressure from main competitors and customer integration of green product development. Furthermore, empirical evidence is presented for the enabling influences of three dimensions of green supply chain integration on both incremental and radical environmental innovation, simultaneously.

Findings from this study also provide some guidelines for managers to direct their management actions to counter environmental management competitive pressure from main competitors by developing their own environmental innovation advantage. In particular, better external integration of green product development may be achieved by first paying attention to internal integration. Managers can work on either internal integration or customer integration of green product development when observing main competitors' green success. In addition, internal integration and external customers and suppliers integration of green product development are effective enablers for enhancing both incremental and radical environmental innovation. However, since financial and human capital resources within an organization are limited, managers might choose the most effective investment for developing environmental innovations. To create incremental environmental innovation, managers can involve internal cross-function team or suppliers. To improve radical environmental innovation, integrating customers is a better choice.

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# APPENDIX 4.A: CONSTRUCT ITEMS

| Construct | Label | Items |
|---|---|---|
| Environmental management competitive pressure from main competitors | COM1 | Our main competitors that have implemented environmental management benefited greatly. |
| | COM2 | Our main competitors that have implemented environmental management are perceived favorably by customers. |
| | COM3 | Our main competitors that have implemented environmental management became more competitive. |
| Internal integration of green product development | INT1 | Manufacturing is involved to a great extent before the introduction of new environmentally-friendly products. |
| | INT2 | Manufacturing is involved in the early stages of new environmentally-friendly products development. |
| | INT3 | Manufacturing is involved in the creation of new environmentally-friendly product concepts. |
| | INT4 | We work in teams, with members from a variety of areas (marketing, manufacturing, etc.) to introduce new environmentally-friendly products. |
| Customer integration of green product development | CUS1 | We consult with our customers early in the design of environmentally-friendly products. |
| | CUS2 | We partner with our customers in the design of environmentally-friendly products. |
| | CUS3 | We consult with our customers frequently consulted about the design of environmentally-friendly products. |
| | CUS4 | Customers are an integral part of the design of environmentally-friendly products. |
| Supplier integration of green product development | SUP1 | Suppliers were involved early in the design of environmentally-friendly products. |
| | SUP2 | We partnered with suppliers for the design of environmentally-friendly products. |
| | SUP3 | Suppliers were frequently consulted about the design of environmentally-friendly products. |
| | SUP4 | Suppliers were an integral part of the design of environmentally-friendly products. |
| Incremental environmental innovation | IEI1 | We often create new patterns of product that are more environmentally friendly |
| | IEI2 | We often improve an existing product to make it more environmentally friendly. |
| | IEI3 | We often exploit existing technologies to make products more environmentally friendly |
| | IEI4 | We often improve existing processes to make them more environmentally friendly |
| | IEI5 | We often exploit existing technologies to make processes more environmentally friendly |
| Radical environmental innovation | REI1 | We often create radically new environmentally friendly products |
| | REI2 | We often introduce radically new concept innovations to make products more environmentally friendly. |
| | REI3 | We often introduce radical innovations to make processes more environmentally friendly |
| | REI4 | We often develop and introduce radically new environmentally friendly technologies into the industry |
| | REI5 | We are often the creator of radically new environmentally friendly techniques and technologies |

**Table 4.1: Demographic data (230 respondents)**

| | N | Percentage |
|---|---|---|
| *Industry* | | |
| NAICS 31-33 (Manufacturing) | 187 | 81.3% |
| NAICS 51 (Information) | 13 | 5.7% |
| Other NAICS | 30 | 13.0% |
| | | |
| *Respondents* | | |
| **Gender** | | |
| Male | 191 | 83.0% |
| Female | 39 | 17.0% |
| **Age** | | |
| 20-30 | 7 | 3.0% |
| 31-40 | 30 | 13.0% |
| 41-50 | 84 | 36.5% |
| 51-60 | 85 | 37.0% |
| 61 or more | 24 | 10.5% |
| **Work Experience** (years) | | |
| <5 | 5 | 2.2% |
| 5-10 | 6 | 2.6% |
| 11-20 | 57 | 24.8% |
| 21-30 | 85 | 37.0% |
| 31-40 | 68 | 29.5% |
| >41 | 9 | 3.9% |

**Table 4.2**: Descriptive statistics and correlations matrix

| | Mean | Std. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Environmental management competitive pressure from main competitors | 4.07 | 1.15 | 1 | | | | | | | |
| 2. Internal integration of green product development | 4.53 | 1.35 | .422** | 1 | | | | | | |
| 3.Customer integration of green product development | 4.24 | 1.38 | .452** | .650** | 1 | | | | | |
| 4.Supplier integration of green product development | 4.25 | 1.39 | .397** | .613** | .667** | 1 | | | | |
| 5. Incremental environmental innovation | 4.62 | 1.32 | .456** | .686** | .657** | .610** | 1 | | | |
| 6. Radical environmental innovation | 3.35 | 1.46 | .392** | .536** | .625** | .544** | .676** | 1 | | |
| 7. Firm size (Log Sales) | 2.90 | 0.945 | .209** | .218** | .239** | .225** | .331** | .282** | 1 | |
| 8. R&D expense | 151.7 | 456.1 | .137 | .145 | .142 | .186* | .229** | .222** | .433** | 1 |

*** significant at the 0.01 level   * significant at the 0.05level*

**Table 4.3:** Convergent validity and reliability

| Construct | Label | Standardized Loading | Cronbach's Alpha | Composite Reliability |
|---|---|---|---|---|
| Environmental management competitive pressure from main competitors | COM1 | .796 | .899 | .950 |
| | COM2 | .864 | | |
| | COM3 | .897 | | |
| Internal integration of green product development | INT1 | .959 | .936 | .964 |
| | INT2 | .979 | | |
| | INT3 | .939 | | |
| | MON4 | .847 | | |
| Customer integration of green product development | CUS1 | .953 | .958 | .978 |
| | CUS2 | .983 | | |
| | CUS3 | .966 | | |
| | CUS4 | .925 | | |
| Supplier integration of green product development | SUP1 | .889 | .961 | .971 |
| | SUP2 | .947 | | |
| | SUP3 | .964 | | |
| | SUP4 | .970 | | |
| Incremental environmental innovation | IEI1 | .955 | .982 | .984 |
| | IEI2 | .979 | | |
| | IEI3 | .969 | | |
| | IEI4 | .959 | | |
| | IEI5 | .946 | | |
| Radical environmental innovation | REI1 | .984 | .967 | .991 |
| | REI2 | .981 | | |
| | REI3 | .967 | | |
| | REI4 | .988 | | |
| | REI5 | .974 | | |

**Table 4.4:** Discriminant validity test

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1. Environmental management competitive pressure from main competitors | **.728** | .178 | .204 | .158 | .208 | .154 |
| 2. Internal integration of green product development | .422** | **.869** | .423 | .376 | .471 | .287 |
| 3.Customer integration of green product development | .452** | .650** | **.916** | .445 | .432 | .391 |
| 4.Supplier integration of green product development | .397** | .613** | .667** | **.889** | .372 | .296 |
| 5. Incremental environmental innovation | .456** | .686** | .657** | .610** | **.925** | .457 |
| 6. Radical environmental innovation | .392** | .536** | .625** | .544** | .676** | **.958** |

*Note: Diagonal entries (in bold) are average variances extracted, entries below the diagonal are correlations, and the entries above the diagonal represent the squared correlations.*
*** significant at the 0.01 level*

**Table 4.5:** Mediation test (Baron and Kenny (1986) test)

| Paths | M1 | M2 |
|---|---|---|
| COM to CUS | .376*** | .119** |
| COM to SUP | .300*** | .040 |
| COM to INT | | .282*** |
| INT to CUS | | .805*** |
| INT to SUP | | .803*** |

***significant at 0.001 level; **significant at the 0.01 level

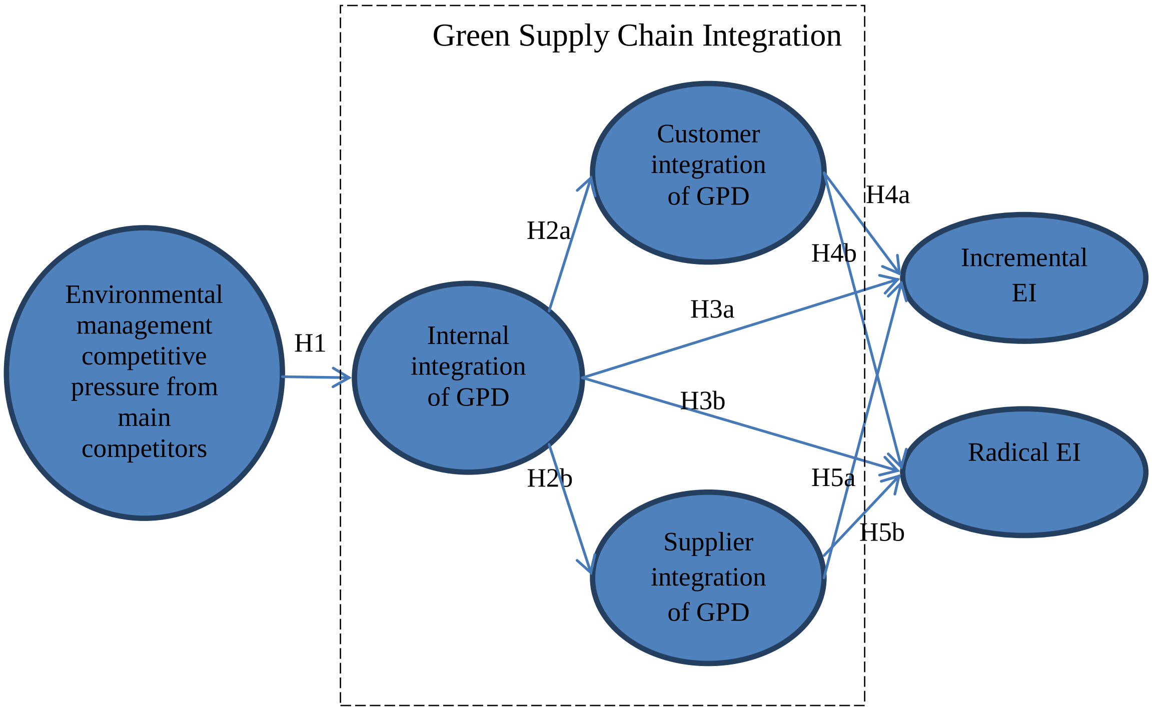
Note: Although not listed in the table, M1 include the relationships between customer integration of green produt development and both incremental and radical environmental innovation, and include the relationships between supplier integration of green product development and both incremental and radical environmental innovation; M2 include all relationships between green supply chain integration (internal, customer, supplier) and both incremental and radical environmental innovation.

**Table 4.6:** Test of alternative models

| | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| COM to INT | 0.289*** | - | 0.367*** |
| INT to CUS | 0,840*** | - | - |
| INT to SUP | 0.814*** | - | - |
| COM to CUS | - | 0.376*** | 0.423*** |
| COM to SUP | - | 0.300*** | 0.347*** |
| CUS to INT | - | 0.618*** | - |
| SUP to INT | - | 0.438*** | - |
| | | | |
| *Model fit index* | | | |
| $\chi 2$ | 667.008 | 837.881 | 1096.039 |
| Df | 311 | 310 | 311 |
| $\chi 2$/Df | 2.14 | 2.70 | 3.52 |
| CFI | 0.966 | 0.949 | 0.924 |
| TLI | 0.961 | 0.943 | 0.915 |
| RMSEA | 0.070 | 0.086 | 0.105 |
| AIC | 14306.425 | 14479.298 | 14735.456 |

***significant at 0.001 level;

Note: Although not listed in the table, M2 and M3 both include the relationships between green supply chain integration and environmental innovation as suggested by H3a,b, H4a,b and H5a.b in M1. The results are also similar with those in M1.




GPD: green product development;
EI: environmental innovation

***Figure 4.1.*** *Conceptual Model*

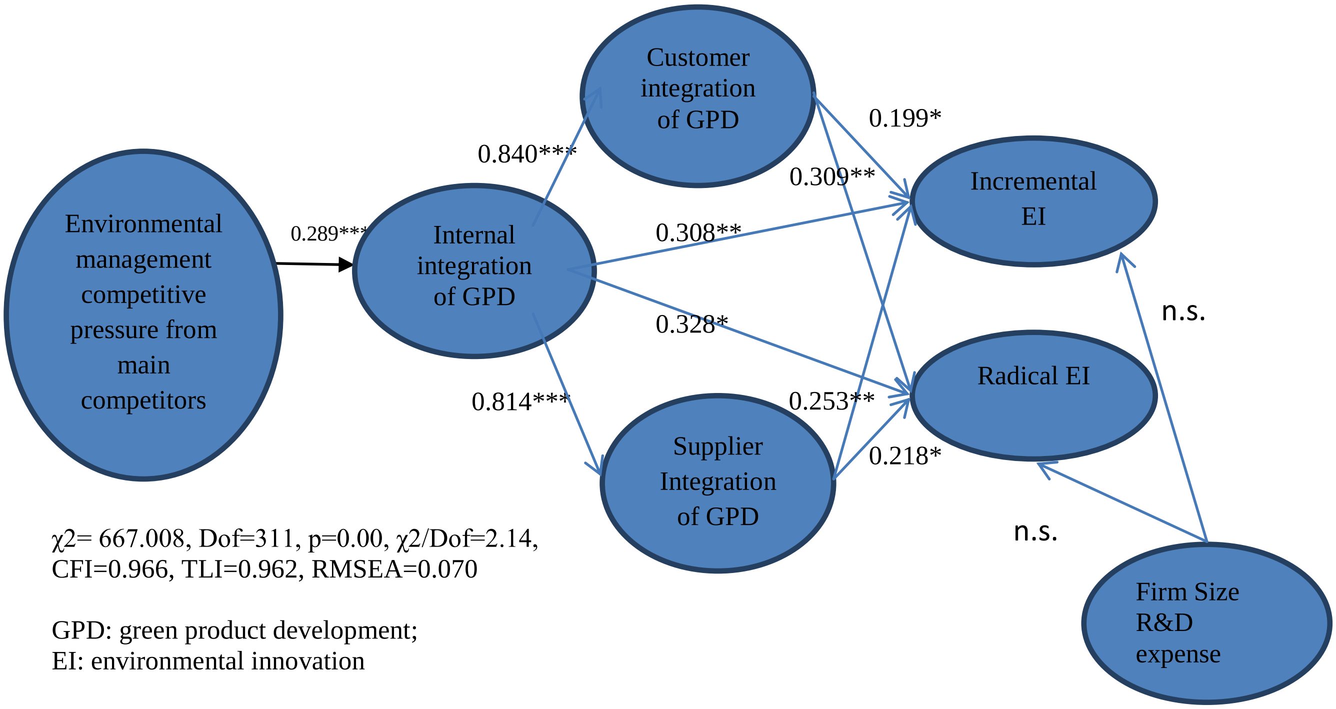



***Figure 4.2.*** *Model Results*

# CHAPTER 5

# GENERAL CONCLUSION AND FUTURE RESEARCH

This dissertation is a collection of three essays on examining related issues in green supply chain management. It is motivated by the increasing attention to the environmental sustainability and underlying complexities along the implementation of green supply chain management activities. Our studies address the recent call for studies that advance green supply chain management research.

## 5.1 General Contribution

This three-essay dissertation makes two important contributions. First, this dissertation adopts multi-theoretical lens to examine important issues in the green supply chain management. Green supply chain management is a new and growing research area, and thus adopting existing theory into this new domain could bring new implications. In the first essay, a strategy-structure-capabilities-performance (SSCP) perspective is apdtopted to develop a model how a firm's proactive environmental management strategy influences innovation and operational performance. In the second essay, recognizing that there are different pressures to drive the implementation of green supply management, stakeholder theory and the Schumpeterian view of competition is incorporated together to develop the model which examines the effect of top management support in response to rival and stakeholder pressures to implement green supply management practices. In the third essay, the Schumpeterian perspective of competition and supply chain integration theory is drawn upon to build the research model. I propose that competitors' green success drives a focal firm to introduce environmental innovations to the marketplace. The coordinating mechanism between internal integration and external integration of green product development is also necessary.

Secondly, using survey data collected from a sample of supply chain professions in the US public traded companies, this dissertation offers empirical evidence and thus provides managerial implications. The first essay supports the claim that corporate environmental proactivity is important for a firm's operational performance improvement. It also indicates that environmental collaboration with suppliers and environmental innovation development enhances a firm's ability to improve operational performance. Collaborating with suppliers on environmental management increases incremental and radical environmental innovation and ultimately both types of environmental innovation pay off in terms of reduced production cost, improved quality, delivery and flexibility of the products. Thus companies aspiring to increase environmental innovation and operational performance may need to better align their corporate environmental strategy and the environmental management practice across the supply chain. The second essay offers empirical support for the role of top management support in linking rival pressure, stakeholder pressure and three dimensions of green supply management implementation. Top management support is seen as necessary for the organization to secure important resources and to provide leadership in uncertain circumstances. The findings highlight the importance of how managers must take an active role in promoting green supply chain management among its supply base. Thus, obtaining and maintaining top management support is required in order to achieve effective response to rival pressure and stakeholder pressure. The empirical results in the third essay demonstrate main competitors' green success is an important reason for a firm to collaborate internally and externally with suppliers and customers to develop green products. Findings from this study also provide some guidelines for managers to direct their management actions to counter a rivals' green success by developing their own environmental innovation advantage. In particular, better external integration of green product development may be achieved by first paying attention to internal integration. Managers can work on either internal integration or customer integration of green product development when observing main competitors' green success. In addition, internal integration and external customers and suppliers integration of green product development are effective enablers for enhancing both incremental and radical environmental innovation.

## 5.2 Future Research

While this research has made an important contribution to the literature, there are several opportunities for future research. First, these three essays are conducted by survey data. Given the limitation of single source of data, future research can validate or retest the models by combining primary data and secondary data. For example, environmental innovation can be measured using patent data.

Second, the sample in this dissertation is from the US based companies. Since global sourcing is more and more important, green supply chain management should be examined in the global context. It would be interesting to examine if national culture would have significant impact on the implementation of green supply chain management. Cross-countries comparison research is also needed in order to further the understanding of green supply chain in the global context.

Third, in the models proposed in the essay 1 and essay 3, the outcomes of green supply chain management activities are focused on environmental innovation and operations management. Future research could extend to other performance measures, such as financial performance and market performance, in order to provide more managerial implications.

Fourth, this dissertation has presented several drivers of green supply chain management implementation, such as proactive corporate environmental strategy, top management support, stakeholder pressure and main competitors' green success, but more investigation is needed for the determinants of green supply chain management in order to further the understanding of the ration for those actions or decisions. One possible research area is to see if the power difference in the supply chain partners would influence the implementation of green supply chain management.

Fifth, we should not only examine the determinants of the implementation of green supply chain management, but also examine if those determinants would influence the success of green supply chain management implementation. For example, in the second essay, the role of top management support in enabling the implementation of green supply management in the organization is highlighted. Future research should investigate if top management support has significant influences to support firm implement green supply chain management successfully and achieve competitive advantage through green supply chain management.

Lastly, interdisciplinary aspects of green supply chain would be interesting and important research areas. Here is a potential research questions list although it is not complete. 1) Are green supply chain management and quality management (lean, six sigma…) complementary? 2) Does capability/experience to manage risk in the supply chain leads to implementation of green supply chain management successfully? 3) In the interface of green supply chain management and management information system, what's the role of information sharing in green supply chain management? How do IT capacities support the green supply chain integration? 4) In the interface of green supply chain management and marketing, how green supply chain integration for green product development impact marketing strategy and market performance? Hopefully, this dissertation provides the inspiration to encourage such research.